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PROCEEDINGS

OF THE

Royal

PHILOSOPHICAL SOCIETY OF GLASGOW.

VOL. V.

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PROCEEDINGS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW.

FIFTY-NINTH SESSION.

Anderson's University Buildings, November 7, 1860.

THE fifty-ninth session of the Philosophical Society was opened this evening,—Dr. Anderson, the President, in the chair.

Mr. Montgomery Paterson, manufacturing chemist, was elected a member of the Society.

DR. ANDERSON delivered an opening address. He commenced by congratulating the members on the present condition and future prospects of the Society. During the past session very important changes had been introduced in the business of the Society; and among these the more frequent publication of the Proceedings held the first place, and had proved most advantageous, having brought out a copious supply of valuable contributions to its pages. The Library also was rapidly increasing, and was becoming a very valuable collection of scientific works, and becoming every year more useful to the members, and more extensively consulted.

He then proceeded to take a short survey of some of the more important chemical investigations which had been made during the past year. Among the most remarkable of these are the researches which have been made into the general distribution of some elements which have hitherto been considered to be the most distinctly localized; and on this subject the important researches of Kirchoff and Bunsen are of peculiar importance, because they not only detect some of those substances in unexpected localities, but furnish the chemist with a new instrument of investigation. They have shown that the coloured flames produced when certain oxides are introduced into a gas flame, when analyzed by means of the prism, show spectra which are highly characteristic of the substances; and as the colours are produced by a quantity which is almost infinitesimally small, the examination of the spectrum affords a means of determining the presence of those substances

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which, in point of delicacy, infinitely transcends the best chemical reactions, and in many cases, as in the alkalies, affords a peculiarly exact means of detecting them. Soda, for example, causes the whole of the colours of the spectrum to disappear, with the exception of one bright yellow band, corresponding with Frauenhofer's line D. The spectrum produced by the lithium compounds is also highly characteristic, and consists of two very distinct red lines, the one more intense than the other. By the assistance of these lines it has been shown that lithium, which was once considered to be one of the rarest of the elements, is very widely distributed. It is found in sea-water, the ash of sea plants, in many mineral waters, and in land plants. The milk of animals fed on wild plants contains it, and it has also been shown to exist in human blood; and it will be possible to obtain it from many sources in which, owing to the imperfect nature of the reactions previously known, its existence has been overlooked. The flames given by the compounds of barium, strontium, calcium, and potassium, are scarcely less characteristic than those just mentioned, and enable each of these substances to be detected with unerring accuracy when they are present in the minutest trace. Not only, however, is the spectrum analysis a most conclusive means of detecting the known elements, but it affords a means of discovering those which, from their existing in very minute quantity, have hitherto escaped notice; and Bunsen and Kirchoff have already detected a new alkaline metal, giving a spectrum consisting of two blue lines, and they are now engaged in the endeavour to obtain a sufficient quantity to enable them to investigate its chemical properties.

A recent investigation by Mr. Dugald Campbell has shown the very wide distribution of two metals belonging to a very different class. He has found that arsenic and antimony are very generally present in sand of rivers, &c. In fact, no specimen of sand yet examined has been found free from them, and this not in doubtful traces, but in unmistakeable quantity. It is well known that the occurrence of arsenic in the soil is by no means rare; and it is also met with in the ochery deposit frequently found in some waters; but Mr. Campbell's observations trace it back to its source, and it is probable that when the experiments have been extended, these substances will be found in most rocks.

Bousingault, who has long devoted himself to the detection of nitric acid, has also shown that it is obtained from many unexpected sources; and after having detected it in rain and snow waters, in rivers, the soil, and other substances, in which its presence is clearly due to the decomposition of nitrogenous organic matters, he has also found it in native manganese and other purely inorganic substances.

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It is impossible to look at these investigations without seeing that they point to conclusions at variance with many of our preconceived notions. They show that so far from particular elements being restricted to individual portions of the earth's surface, they must be considered as all being generally distributed. In fact, it would appear that wherever we possess a sufficiently delicate reaction for any substance, its presence may be detected almost everywhere; and we cannot doubt that in those cases in which we only know substances in one or two localities, our failure to discover them elsewhere is not due to their absence, but mainly to the want of discriminative tests.

The researches on the metals, which have been a favourite subject with chemists, have this year borne their fruits, and, among others, a French chemist, M. Caron, has shown that it is possible to obtain calcium in large quantity. He finds that while the chloride of calcium cannot be decomposed by means of sodium alone, the experiment succeeds perfectly if the iodide be employed; and if heated in a close crucible, with the proper quantity of sodium, the exact equivalent of the earthy metal can be obtained. And this process is instructive; for it recalls to our minds the difficulties experienced by Davy when he first used potassium as a reducing agent. In preparing boron, silicium, and some other metals, he caused it to act upon their oxides, and he had thus to overcome a very powerful affinity. Berzelius substituted the fluorides for the oxides, and at once the reduction became comparatively easy. Oerstedt then introduced the use of the chlorides in certain cases; now we have the iodides; and there may yet be found opportunities of advantageously using some of the other compounds.

Deville has also, during the past year, prosecuted his researches into the action of high temperatures, and their application to the fusion of refractory metals, and has now, by means of sufficiently large jets of gas, alimented with oxygen, succeeded in fusing half a hundredweight of platinum, and casting it into a solid ingot. He has also devoted the experience thus obtained to the determination of the vapour density of substances of high boiling points, and has, by the use of balloons of porcelain, the points of which are fused by the oxyhydrogen blowpipe, succeeded in obtaining accurate results with substances of very high boiling points.

The applications of chemistry to the useful arts, though bearing their usual share of valuable results, do not call for very particular notice here. The subject of most interest, and which has given rise to a large number of patents, is the production of colours from aniline. By the application of different re-agents a variety of different tints of great beauty have been obtained; and though it is understood that none of them are so permanent as the original purple, they have all found uses

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in the hands of the calico printer. The interest which attaches to this subject, however, appears to be mainly due to its indicating the great unworked field which organic chemistry offers to the arts. That branch of the science has accumulated an immense mass of materials, to which the attention of the manufacturing chemist has as yet been scarcely directed, or which he believes quite incapable of affording useful results. The history of aniline is a practical refutation of such views. Ten years since it was impossible to conceive any substance less likely to prove useful in the arts; and it cannot be doubted that there are many other departments of the science destined to yield as prolific a harvest of valuable applications. It only remains for the manufacturer to devote more attention than he has latterly done to the study of chemistry, by which is to be understood not a mere superficial knowledge of its elements, but an intimate acquaintance with its details, to enable him to find numerous uses for substances which at present he is inclined to rank only in the list of curiosities, although, if attention were properly directed to them, uses would soon be found for them in the arts.

Fossil Rain-markings and Fucoid Impressions on the Sandstone of Scrabo Hill, near Newtonards. By James Bryce, LL.D., F.G.S.

Specimens of these markings were exhibited on slabs from the Scrabo quarries, where they were discovered by Mr. Robert Young, C.E., of Belfast, in August last. The impressions of the rain-drops are sufficiently distinct and characteristic; those of the fuci were at first supposed to be the footprints of some animal, to which indeed they bear much resemblance. Both are the more interesting that this sandstone has not as yet yielded any fossils, is of uncertain age, and in these quarries is pervaded by a singular reticulation of whin dikes. The section was described in which this sandstone is embraced, and which extends from the permian beds on the east side of Belfast bay to the carboniferous limestone of Castle-Espie, near Comber. Abounding in well-marked fossils at either extremity, the beds in the middle portion are singularly barren, and hence the uncertainty as to age, though there seems little doubt that they belong to the lower part of the carboniferous formation. Among these beds borings have often been made in search of coal, but without success as yet. Rain-prints have, however, been found at a lower horizon than this—even as far down as the Cambrian rocks. The geological history of rain-markings was shortly noticed; and also those conditions of the earth's surface and the earth's atmosphere, which the phenomena attending them have brought to light.

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November 21, 1860.—*The* PRESIDENT *in the Chair.*

The following gentlemen were elected members of the Society, viz.: —Mr. David Guthrie, C.E.; Mr. John Mayer, Certificated Teacher of Chemistry; Mr. Robert Smith, Merchant; Mr. Robert Gow, Accountant; Mr. James Harold.

Mr. Cockey presented the following Abstract of the Treasurer's Account for the Session of 1859-60:—

DR.

1859.—*Nov.* 1.						
To Cash in Union Bank,	£106	1	0			
Do. in hands of Treasurer,	2	12	9			
				£108	13	9
Entries of 24 new Members, at 21s.,	25	4	0			
Annual Payments from 5 Original Members at 5s.,	1	5	0			
Do. from 276 Members, at 15s.,	207	0	0			
Do. from 2 Members in Arrear, at 30s.,	3	0	0			
				236	9	0
M. Connal, Esq., for use of Hall,				0	10	0
Institution of Engineers, for Rent of Hall,				15	0	0
Interest allowed by Union Bank,				2	15	3
				£363	8	0

CR.

1860.—*Nov.* 1.						
By New Books Purchased,	£122	10	10			
Binding,	10	2	0			
				£132	12	10
New Bookcase, Gas Fittings, and Painting,				13	14	0
Stationery,				1	8	9
Diplomas for new Members,				7	6	0
Printing and Illustrating Transactions of the Society,				58	1	6
Printing Circulars of Meetings,				12	18	0
Salary to Society's Officer,	£52	0	0			
Fee to Officer of Andersonian University,	3	0	0			
Do. to Clerk for engrossing Minutes,	1	1	0			
Blackwood, for delivering Circulars,	9	2	8			
				65	3	8
Rent of Hall,	45	0	0			
Fire Insurance,	6	7	8			
Gas,	1	18	0			
				53	5	8
Subscription to Social Science Association,				1	1	0
Petty Charges,				3	19	10
Balance in the Bank,	10	0	3			
Do. in Treasurer's hands,	3	16	6			
				13	16	9
				£363	8	0

GLASGOW, *October* 31, 1860.—We have examined the Treasurer's Accounts, of which the above is an Abstract, and compared the same with the Vouchers. We find that there is in the Union Bank the sum of £10 0s. 3d., and in the Treasurer's hands, £3 16s. 9d., together, £13 16s. 9d., to the credit of the Society at this date.

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The Treasurer has also exhibited to us a Voucher which he holds for money lent to the Corporation of Glasgow, from the proceeds of the Society's Exhibition in 1846, amounting, with interest to 15th May last, to £803 6s. 4d.

(Signed) H. CONSTABLE.
WM. RAMSAY.

The Society appointed the following gentlemen to be its Office-bearers for the year 1860-61:—

President.

PROFESSOR W. J. MACQUORN RANKINE, LL.D.

Vice-Presidents.

PROFESSOR HENRY D. ROGERS.
MR. ALEXANDER HARVEY.

Librarian.

JAMES BRYCE, LL.D.

Treasurer.

MR. WILLIAM COCKEY.

Joint-Secretaries.

MR. ALEXANDER HASTIE. | MR. WILLIAM KEDDIE.

Council.

PROFESSOR W. THOMSON, LL.D.
MR. WALTER CRUM, F.R.S.
MR. ROBERT BLACKIE.
MR. GEORGE SMITH.
DR. FRANCIS H. THOMSON.
MR. EDMUND HUNT.
MR. JAMES R. NAPIER.
MR. RICHARD S. CUNLIFFE.
PROFESSOR GRANT.
MR. WILLIAM RAMSAY.
MR. ROBERT HART.
DR. ALLEN THOMSON.

On the Geological Structure of Ben-Nevis. By DR. BRYCE.

THE author had satisfied himself, on examining Ben-Nevis and the adjoining mountains in July last, that the accounts which we possess of their geological structure are defective in many respects; and as regards the views now held by geologists, very misleading to the student. A survey of Ben-Nevis on all sides, and an ascent to its summit twice, showed him that granite does not rise anywhere on the mountain or its flanks to a greater height than about 1,600 to 1,800 feet. The great mass consists of basalts, greenstones, and porphyritic traps, with metamorphic-clay slate; the igneous products being very analogous to

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those which, in Arran, overlie sandstones of carboniferous age. In one place towards the line of junction of these rocks with the granite, a mass of the latter was found enclosed in basalt. A section was exhibited showing the relations of these rocks. Slate forms the floor of the valley on the west, rising a little above the level of the road and the river Lochy: the slate is of the silicious or flinty type, mica slate or gneiss nowhere appearing except on the south-east side. The slate is followed by granite as we ascend; this continues to the height indicated already, when the rocks above mentioned succeed, and continue to the summit, forming the entire irregular, broken, and sloping plateau of which the broad top of this singular mountain consists. The grand precipices on the north and north-east, certainly 1,500 feet sheer down, consist wholly of the igneous rocks and slate; the line of junction with the granite rapidly plunging into the northern glen, until it strikes the river bed a little more than half way up. In this way granite shows only on the base of the precipices towards the extreme south-west, dipping underneath the metamorphic and igneous rocks, as sandstone below trap on the hills near Glasgow, or as chalk below the basaltic rocks in the glens of Antrim. In this manner does the granite encircle the northern glen, rising either way from the river bed along the fronts of the opposite mountains.

The author stated that his examination was of too cursory a kind to entitle him to express a positive opinion as to the origin of this monarch of Scottish mountains, the conditions under which it was elevated, and the relation in which this elevation stands to the vast development of its igneous products. This he hoped to be able to do after another visit and more extended survey. On the authority of Sir Henry James, superintendent of the Ordnance Survey, he had several years ago published the fact, that Ben-Nevis is ascertained to be 110·3 feet higher than Ben-Macdhui, the respective elevations being 4406·3, and 4296 feet.

On the Relations of Deposits of Common Salt to Climate.
By PROFESSOR HENRY D. ROGERS.

PROFESSOR ROGERS commenced this communication by stating that he proposed to show, by a wide induction from facts in physical geography, that whereas the gold fields of the globe are all situated on the wet or oceanic sides of mountain chains, the great salt fields are, with few exceptions, restricted to the dry or continental sides. Without attempting an exhaustive survey of the geographical distribution of gold, which, indeed, the limited time then at his command would

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not permit, he essayed to show that all the chief known gold fields, or districts rich in alluvial gold, lie in the paths of wet oceanic winds. This is eminently true of the two most abounding auriferous deposits—that of California and that of Australia. The third principal gold field in ratio of richness and productiveness—that of the eastern slope and base of the Ural Mountains on the borders of Siberia—is an apparent, but not an actual, exception to the prevailing law enunciated. This great gold field does not, it is true, face any existing ocean, nor is it watered by any particularly humid wind; but the geology of Western Asia and Eastern Europe plainly indicates that during the very modern tertiary ages which witnessed the deposition of the Siberian gold alluvium, the Ural chain from whence this alluvium has been washed was in reality a coast range of mountains fronting a wide tract of shallow Siberian sea, in crossing which the predominant north-east or polar wind must have become what the same wind is now in some longitudes, excessively humid, by the time it impinged against the Urals to drench their eastern flank, and erode, and disperse, and sort their rocky and metallic particles.

Turning to the physical geography of salt, a correlative general law was established of the intimate connection of the superficial salt or modern salt fields of the globe, with dry or inland climates, or prevailingly arid winds. With the aid of Johnston's *Physical Atlas*, it was proved that wherever the dominant winds of a country are very dry the surface waters are more or less salt; that only within their track do we meet with real Caspians, or lake basins, destitute of any outpour or overflow into the general ocean, while, without exception, these land-locked reservoirs contain salt water like the sea, for the obvious reason that they are perennially receiving saline matters collected from the land by the dissolving agency of the atmospheric moisture and the influent streams; but are discharging none, as the whole of the inpoured water goes off in evaporation. The saltness of the general ocean but confirms this law, that the basins without outlets are necessarily saline; for what is it but a mightier Caspian, land-locked like other salt lakes, draining over into no receptacle, but maintaining its balance of supply and waste by evaporating its entire influx into the general atmosphere, excepting only its land-derived salts and its earthy sediments.

The views here presented appeal to the well-admitted chemical facts, that the atmospheric water abstracts saline matters from the rocks and soil wherever it descends upon or into them; and that all the so-called fresh waters of the globe are actually saliferous to a slight extent. A general impregnation of the flowing waters with however trivial an amount of salt, concurring with a state of the atmosphere productive

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of a total evaporation of the whole watery influx, appear to be the sole essential conditions for causing and maintaining any of the surface salt fields and briny lakes which we behold.

Numerous signal instances were adduced of very saliferous districts lying at high elevations above the level of the present ocean, disproving the hypothesis of Von Humboldt and others, who have attempted to account for the earth's Caspians and salt fields by supposing all of them to have been originally tracts deserted by the existing sea, where patches of it had become detached and dried up. The remote geological age of the Salt Desert of Utah, west of the Rocky Mountains, at a height surpassing 4,000 feet, and the antiquity of the saliferous basin or Plain of Titicaca in the Andes, at an elevation of nearly 12,000 feet, were cited as incompatible with such a source for their saltness.

Adverting to the distribution of stratified rock salt in the older geologic formations, the author of the paper pointed to a conspicuous exception, more seeming than real, he conceives, to the law he has enunciated, of the connection of such deposits with arid or desert climates. This exception is the salt-bearing deposit of Cheshire, a climate now notoriously wet, and one in which no saline accumulations are possible from natural evaporation. As the geological age of this deposit is extremely remote, we are not entitled to assume that the existing physical geography at all represents that which prevailed in the west of England and in the region of the Atlantic during the Triassic ages, which beheld the accumulation of the Cheshire salt beds; but are warranted in conceiving that arid lands, and perhaps high mountains, may have interposed between the salt-receiving district and the nearest western sea to dry out the humidity from the atmosphere which then, as now, must in this latitude have flowed in upon Europe with a strongly predominant motion from west to east.

The communication closed with some statistical statements regarding the vast amounts of pure crystalline salt and rock gypsum which have been seen by travellers in the semi-desert and desert plains of the interior of North America, in districts which exemplify in a striking manner the connection of both of these substances with aridity of climate.

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December 5, 1860.—PROFESSOR W. J. MACQUORN RANKINE, *the President, in the Chair.*

Dr. Edward W. Pritchard and Mr. Thomas Rowan were elected members.

The Society agreed, on the motion of Mr. Cockey, the Treasurer, to limit the outlay on the purchase of books this session to £50, exclusive of periodicals.

Notes of a Tour in Iceland in 1859. By DAVID MACKINLAY, Esq.

MR. MACKINLAY read an account of a journey in the north of Iceland in 1859, in continuation of his paper read to the Society on the 30th of November, last year, and describing a visit to the southern shores of the island (see Vol. iv. of *Proceedings*). He set out from Reykiavik, the capital, on the 7th of July, and the journey occupied eighteen days. The route was by Hoalfiord, Reykholtsdalr, and the uninhabited wilderness in the centre of the island. The following are some extracts from this interesting communication:—

"At the bottom of the lake of Korrudulr we traversed a forest of considerable extent. The trees were birch and willow. The willows of Iceland are so small that one feels a compunction of conscience in speaking of them as trees; the birches vary in height from two to eight feet; few of them, however, exceed four feet. In former times the climate of Iceland seems to have been more favourable to the growth of timber, as trunks of trees, one to two feet in diameter, are occasionally dug out of the bogs. Speaking of bogs, I may mention that they form one of the difficulties of Iceland travel. They are covered with vegetation, the roots of which are so matted together as to make a bridge strong enough, in most cases, to bear the weight of both horse and rider. Occasionally, however, the bridge fails, and down sinks the horse suddenly to the girths. But it is surprising with what sagacity the horses pick their steps through them. When they come to the more suspicious looking spots they stop, and insist on making a detour to look for better footing. On such occasions it is usually best to let them have their own way. Reykholtsdalr is one of the lateral valleys which opens into the great valley of the Hvitá, or White River. Our course led for some distance along the latter valley, but not within sight of the river (which is the largest in the west). Geodes of quartz projected here and there from the trap rock, and zeolites in great abundance sparkled in the sunshine. Reykholtsdalr is twelve or fourteen miles long, and has a breadth of one to two miles. It has long been

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celebrated for its hot springs, of which there are about fifteen groups. Eight of them are visible from the church of Reykholt. We saw the more important groups on our way up the valley. One of them was very interesting; but, unfortunately, it was so shrouded in steam that we saw it only imperfectly. It consists of sixteen boiling springs, which yield water enough to fill a brook of moderate size. They are situated in boggy ground, close to the foot of a steep silicious bank, twelve or fifteen feet high, which feels warm even on the surface, in consequence of its being permeated by hot steam from some subterranean crevices. Two of the springs erupt alternately, and with considerable noise; but the height of the jet does not exceed six or eight feet. We could hear the eruption well enough, but, unfortunately, we could not see it, as the wind, though brisk, was not strong enough to blow off the vast clouds of steam which obscured the springs. It was only now and then that a sight of even the outer ones could be obtained. I went as near the springs as I safely could, in the hope that a favouring blast would expose the inner ones to view. The blast came, but in place of showing the springs, it brought a cloud of steam about me, which shut out the view of everything, and for a time prevented my retreat. Another most interesting group of springs is situated on a sandbank in the river which waters the valley. Where the bank was nearly level with the water arose three springs, whose mouths were filled with gravel. Through this gravel the steam and water issued forth with a crackling noise, and an appearance as of thousands of peas dancing on the surface. At the lower end of the sandbank is an isolated rock, wholly composed of silicious sinter and gravel; it rises with steep sides about seven feet, and is ten feet by twenty across; several springs issue from the top, but not all at the same level. The highest one boils violently, throwing up the water eighteen to twenty-four inches, in considerable quantity. Near it is one two feet by four across, which boils calmly, and gives out much less water. All the springs which I examined had an alkaline reaction.

"The next day's journey led us to the great central desert plain. In the course of the forenoon we passed through an extensive birch forest, which reminded me much of one of the juniper glades in the forest of Fontainbleau. The ground here was very uneven, as it rested on an old lava bed. The highest of the trees did not exceed seven feet; but some beautiful little wild flowers—geraniums, pink-coloured sedums, &c.—flourished under their shelter."

The celebrated cave of Surtshellir was visited:—

"It would be better perhaps to describe this as a tunnel than a cave. It is about a mile (5,034 feet) long, and nearly straight. Its height

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and width vary at different places; but are seldom less than thirty feet, or more than sixty. It seems to have been produced by an accumulation of steam while the lava was fluid and still moving forward. When the steam reached the explosive point it made its escape by blowing up the superincumbent crust of lava in four different places. This crust is twenty to twenty-five feet in thickness. I descended into the cave by the first opening. The descent was easy enough, as the opening was filled with snow to the depth of thirty feet or more. The walls of the cave were red and semi-vitrified, except where masses of stone had fallen off. The bottom was profusely strewn with large sharp blocks of lava which had fallen from the roof. In scrambling along I came to a shallow pool of water, which rested on a bed of ice of unknown depth. The second opening was, like the first, partly filled by the still undissolved snows of the past winter. The part of the cave beyond was difficult to traverse, partly in consequence of the great size of the sharp lava blocks which encumbered the floor, but chiefly in consequence of the darkness, which, about the middle of the passage, was almost total. Here three lateral caves of great size break off from the main one. With the aid of a taper, I got a sight of the mouth of one of these; but my feeble light failed to show the others. In spite of the difficulties of the way, I scrambled on to the third opening. From this I hoped to have made my way to the upper air; but, on climbing up the snow-bank, I found all outlet barred by a perpendicular wall of rock. Beyond this third chimney the tunnel divided into two branches. The left branch was short, but the right extended till it was lost in darkness. I dared not explore it without torches and a guide; and so, after casting a wistful glance at the inaccessible rampart which surrounded me, I dived again into the realms of Pluto, from which I had just emerged. It was hard work and slow scrambling over the rough lava; but by dint of caution, and the liberal use of the tapers, I groped my way into the light of day.

"Before us lay Eyrick's Jökull, a square-shaped volcanic mountain, and the most westerly, at this point, of that enormous range of glacier mountains which occupy the south central and southern parts of the island. This range forms the great water-shed of the country, and gives birth to all the principal rivers. With a few interruptions, it extends from Snaefell's Jökull in the west to Thrándar Jökull in the east. North of this range the great rivers have all a northerly course; and those south of it a southerly or south-westerly course. The south-eastern mass of Jökulls, which covers more than 3,000 square miles, approaches within two to six miles of the coast. Here the rivers, which are large and rapid, spring, as it were, full-formed out of the

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bosom of the thick-ribbed ice. The most dangerous rivers of Iceland are among the shortest. The summer level of the large rivers is more readily affected by hot weather than by heavy rains. The rain-fall makes its way very slowly into the water-courses, owing to the numerous bogs and the want of artificial drainage; but a bright sunny day rapidly swells the out-fall from the Jökulls, and renders rivers impassable, which at other times may be forded with ease.

"The number and size of the rivers cannot fail to strike the attention of every visitor who sees much of the country, especially along the coasts. The main cause of this is, of course, the abundant rain-fall, which is out of all proportion to the latitude of Iceland. This excess is owing to two causes,—the mountainous nature of the country, and its geographical position. Iceland lies in the direct course of one of the branches of the Gulf Stream. No land intervenes between it and the Bermudas. The rain-charged clouds from the south-west are therefore ready to part with their moisture as soon as they touch the shores of Iceland. As they move northward to the backbone of the island their temperature diminishes so rapidly that the whole of their moisture becomes precipitated. Winds from the S.W., S., and S.E. drench the southern part of the island, but bring fair weather to the north.

"As the southerly winds are the most frequent, the north side enjoys the greatest number of sunny days in summer; and hence vegetation is more luxuriant there, even though the latitude is 3° higher, and the southerly winds are chilled in passing over the great mountain chain. The mean summer temperature of the north is almost as high as that of the south; but the mean temperature of the year is 14° lower. In the south this is 47°; but in the north it is 33°. The climate of the south is insular in its character, while that of the north is continental. Severe continuous frosts are rare about Reykiavik; while all along the north coast the winters are very severe. The severity of the winters is mainly caused by the presence of ice in the adjoining seas. The cold arctic current from Spitzbergen, which impinges on the north coast, comes freighted in winter with an occasional iceberg; while the westerly winds and the west Icelandic branch of the Gulf Stream combine to fill the seas to the north and east of the island with ice floes from Greenland. In ordinary winters the seas to the south and west are open but in extraordinary winters they also are filled. Such a winter was that of 1858-9. The corresponding winter here was very mild, and owed its mildness to the same cause which produced the hard winter of Iceland—the unusual prevalence of westerly winds. In the first months of 1859 the sea between Greenland and Iceland—200 miles wide—was packed with ice floes; and upon these several bears made their way across to

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N. Iceland. Floating ice surrounded the island; but along the north coast the sea itself was frozen so far out that the people of Grimsey, twenty miles or so from the nearest point of Iceland, actually rode across to the mainland. At Akur Eyri, in the beginning of April, Reaumur's thermometer registered 26° of cold—a temperature equal to —26½° of Fahrenheit. So late as June, seven French fishing boats were lost in the ice on the north coast, and a French ship of war nearly met with the same fate. Speaking of northern ice, Captain Launay, of the French man-of-war referred to, told me that its approach could be foreseen at the distance of twenty-five to thirty miles by a peculiar reflection from the sky. As the distance diminishes the sky gets overcast, the temperature falls rapidly, and fish and sea-fowl disappear. The Greenland ice is much more dangerous than the Spitzbergen. The latter is 120 to 150 feet high, massive, and wall-sided, but of no great extent. The former is in immense floes, often forming bays in which ships are caught as in a snare. It seldom exceeds 40 feet in height; but is jagged and peaked. Sometimes drift timber gets nipped between the floes, and is set fire to by the violent friction it sustains. The sound of the crushing ice was described by Capt. Launay as most horrible."

In fording broad rivers, like the Blanda,—"The way leads across a succession of deeps and shallows, and often it is but a step from the one to the other. The shallows, however, are not always distinguishable by the eye, in consequence of the milkiness of the water. Owing to this, and also to the giddiness caused by the rapid current, a curious optical effect is induced. In toiling through the deeps, your companions in front are seen every now and then perched high above the water, as if their horses' limbs had suddenly got three or four feet added to their length."

On the banks of a lake near the Blanda some Icelanders were encamped, who had come to gather Iceland moss:—"This lichen—called *fialla gras* by the natives—is most abundant on the mountain slopes and elevated plains. It is gathered during the night and early morning, as it is best seen when swollen by the dews. The Icelanders make a sort of porridge of it, which is used with milk."

The state of disease in the island was noticed as follows:—"While at Akur Eyir I spent a few hours with Dr. Finnsen, the government physician of the north-east part of the island. He is a grandson of the learned Finn Magnusson, so honourably mentioned by Mackenzie, and whose name has been adopted by his descendants as their family name. I may mention, in passing, that few families in Iceland have surnames, and that none have held them more than three generations. Like most Icelanders, the doctor seems fond of his country and contented with

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his lot. His government salary, which is the chief part of his income, is about £70, and for this he has to take charge of a district nearly as large as Yorkshire. There are only eight medical men in the whole island. As a consequence, the most of those affected with acute diseases are consigned to the hands of ignorant quacks, of whom there is one in almost every farm house. The mortality among young children is very high. This is mainly owing to the extreme prevalence of the convulsive disease called 'Trismus neonotorum.' It is found in all parts of the island, but rages like a plague in the Westmanna islands and adjoining coast, where 64 per cent.* are carried off by it within a fortnight of their birth. Were it not for the extreme productiveness of the women, Iceland would, in course of time, be depopulated. The unusual infantile mortality is mainly owing, I think, to three causes:— 1. The want of personal and domestic cleanliness on the part of the people; 2. the crowding together of households in one small unventilated room; 3. the coarse food given to children. Few mothers suckle their children. For food, they give them first undiluted cow's milk, and a few days after birth they begin to feed them with chewed fish, butter, mutton, and other substances equally unsuitable.

"There are two diseases to which those past the age of childhood are prone—leprosy, that peculiar disease once so common all over Europe, and affections of the liver with hydatids. Leprosy is most frequent near the fishing stations, but liver diseases are found in all parts of the island. On the other hand syphilis, scrofula, and consumption, are rare diseases. Syphilis is almost unknown, and that, too, though the island is yearly visited by two hundred French and Dutch fishing boats. The native medical men allege, that the predisposition to leprosy is somehow or other connected with the indisposition to syphilis. Whether this is so or not I cannot say; and yet, in favour of the opinion, there is the fact, that syphilis was little known in Europe till leprosy began to die out. As for consumption, the chief physician of the island had assured me that he seldom saw a case; and now Dr. Finnsen stated that, in a four-years' practice among a population of at least 8,000, he had met with only two cases. It seems strange that scrofula and consumption should be so rare, notwithstanding the presence of many things, both in the climate and habits of the people, favourable to their development. At first I could account for it only on the supposition, that the evil influences to which children are exposed kill off during infancy those weaklings who, under more favourable circumstances, would grow up and give birth to a degenerate offspring. But it is probable that diet has also something to do

* Schleisner's *Island undersögt fi a et lægevidenskabeligt Synspunkt.*

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with it. The food of the Icelanders is, to a large extent, oleaginous. Milk is in daily use under different forms. Butter is largely used with the stockfish, which they always eat uncooked. Train oil, tallow, and the fat of various kinds of sea-fowl, are also used either pure or mixed with butter; and last, but not least, the liver of the codfish forms, during the fishing season, part of the daily fare of those living near the coast."

As to the commerce of Iceland,—"The chief exports are wool, oil, fish, salted mutton, and knitted socks and mittens. These are bought by the merchants at the factories. One or more factories are to be found at the principal fiords, but Reykiavik has about a dozen of them. The stock of goods on sale at these places includes almost all articles of first necessity.

"For many years the whole commerce of the island was in the hands of the King of Denmark, who farmed the privilege of trade to an incorporated company. Under this system the poor Icelanders were ground to the very dust, as they had to buy and sell at the prices fixed by the company. The country at length became so impoverished, that the king was forced to open the trade to all Danish merchants. Even thus modified, the monopoly was so unpopular that government was induced, about five years ago, to throw the trade entirely open. None took advantage of the freedom of trade till last year, when the Glasgow firm which had the credit of opening up steam communication with the island, established two agencies there, to the great disgust of the Danish merchants, and the delight of the natives."

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December 19, 1860.—*The President in the Chair.*

Mr. Alexander Duncan, Mr. James Anderson Snell, and Mr. Robert H. Penman, were elected members.

On the Motion of the Strings of a Violin. By Professor H. Helmholz, Heidelberg, Honorary Member of the Society. Communicated by Professor William Thomson.

I have been studying for some time the causes of the different qualities of sound, and as I found that those differences depended principally upon the number and intensity of the harmonic sounds, accompanying the fundamental one, I was obliged to investigate the forms of elastic vibrations performed by different sounding bodies. Among such vibrations, the form of which is not yet exactly known, the vibrations of strings excited by the bow of a violin are peculiarly interesting. Th. Young describes them as very irregular; but I suppose that his assertion relates only to the motions which remain after the impulse of the bow has ceased. At least, I myself found the motion very regular as long as the bow is applied near one end of the string, in the regular way commonly followed by players of the violin. I used a method of observing very similar to that of Lissajoux. Already, without the assistance of any instruments, one can see easily that a string moved by the bow vibrates in one plane only—the same plane in which the string itself and the hairs of the bow are situated. This plane was horizontal in my experiments. The string was powdered with starch, and strongly illuminated. One of the little grains of starch, looking like a bright point, was observed by a vertical microscope, the object lens of which was fixed to one of the branches of a tuning fork. The fork, making 120 vibrations in the second, was placed between the branches of a horse-shoe electro-magnet, which was magnetized by an interrupted electric current, the number of interruptions being itself 120 in the second. In that way the fork was kept vibrating for as long a time as I desired. The lens of the microscope vibrated in a direction parallel to the string, and therefore perpendicular to its vibrations. The string I used was the third string of a violin, answering to the note A, tuned a little higher than common, to 480 vibrations, and, therefore, it performed four vibrations for every one of the tuning fork. Looking through the microscope, I observed the grain of starch describing an illuminated curved line, the horizontal abscissæ of which corresponded to the deviations of the tuning fork, and the vertical ordinates to the deviations of the string. I found it a matter of importance to use a violin of most perfect construction, and I had occasion to get a very fine instrument of Guadanini for these experiments. On the

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common instruments of inferior quality I could not keep the curve constant enough for numbering the little indentures, which I shall describe afterwards, although the general character of the curve was the same on all the instruments I tried. The curve used to move by jerks along the line of abscissæ, and every jerk was accompanied by a scratching noise of the bow. On the contrary, with the Italian instrument, and after some practice, I got a curve completely quiescent as long as the bow moved in one direction, the sound being very pure and free from scratching.

We may consider the motion of the string as being compounded of two different sets of vibrations, the first of which is the principal motion as to magnitude. Its period is equal to the period of the fundamental sound of the string, and it is independent of the situation of the point where the bow is applied. The second motion produces only very small indentures of the curve. Its period of vibration answers to one of the higher harmonics of the string. It is known that a string, when producing only one of its higher harmonics, is divided into several vibrating divisions, of equal length, being separated by quiescent points, which are called nodes. In all the nodes of the second motion of the string in the compound result at present considered, the principal motion appears alone; and also in the other points of the string the indentures corresponding to the second motion are easily obliterated, if the line of light is too broad.

The principal motion of the string is such that every point of it goes to one side with a constant velocity, and returns to the other side with another constant velocity.

Fig. 1 represents four such vibrations, corresponding to one vibration of the fork. The horizontal abscissæ are proportional to the time, the vertical ordinates to the deviation of the vibrating point. Every vibration is formed on the curve by two straight lines. The curve is not seen quite in the same way through the microscope, because there the horizontal abscissæ are not proportional to the time but to the sine of the time. It must be imagined that the curve, Fig. 1, is wound up

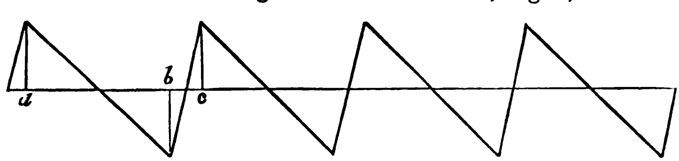


Fig. 1.

round a cylinder, so that the two ends of it meet together, and that the whole is seen in perspective from a great distance; thus is had the real appearance of the curve, as represented in two different positions in Fig. 2. If the number of vibrations of the string is accurately

equal to four times the number of the tuning fork, the curve appears quietly keeping the same position. If there is, on the contrary, a little

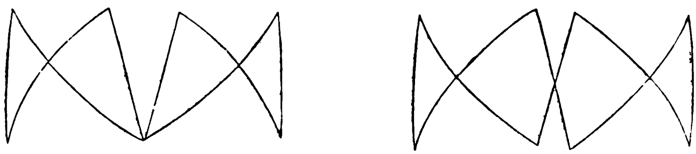


Fig. 2.

difference of tuning, it looks as if the cylinder rotates slowly about its axis, and by the motion of the curve the observer gets as lively an impression of a cylindrical surface, on which it seems to be drawn, as if looking to a stereoscopic picture. The same impression may be produced by combining, stereoscopically, the two diagrams of Fig. 2.

We learn, therefore, by the experiments,—

1. That the strings of a violin, when struck by the bow, vibrate in one plane.

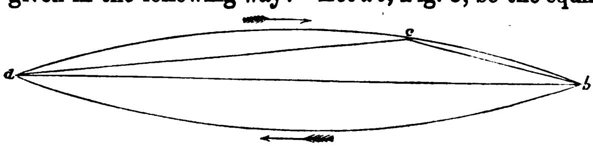
2. That every point of the string moves to and fro with two constant velocities.

These two data are sufficient for finding the complete equation of the motion of the whole string. It is the following:—

$$y = \mathrm{A}\,\Sigma \left\{ \frac{1}{n^2} \sin\left(\frac{\pi\, n\, x}{l}\right) \sin\left(\frac{2\,\pi\, n\, t}{\mathrm{T}}\right) \right\} \text{............1.}$$

y is the deviation of the point, whose distance from one end of the string is x; l, the length of the string; t, the time; T, the duration of one vibration; A, an arbitrary constant; and n, any whole number; and all values of the expression under the sign Σ, got in that way, are to be summed.

A comprehensive idea of the motion represented by this equation may be given in the following way:—Let *a b*, Fig. 3, be the equilibrium



Fig, 3.

position of the string. During the vibration its forms will be similar to *a c b*, compounded of two straight lines, *a c* and *c b*, intersecting in the point *c*. Let this point of intersection move with a constant velocity along two flat circular arcs, lying symmetrically on the two sides of the string, and passing through its ends, as represented in Fig. 3. A motion the same as the actual motion of the whole string is thus given.

As for the motion of every single point, it may be deduced from equation (1.), that the two parts *a b* and *b c*, Fig. 1, of the time of every

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vibration are proportional to the two parts of the string which are separated by the observed point. The two velocities of course are inversely proportional to the times $a\,b$ and $b\,c$. In that half of the string which is touched by the bow, the smaller velocity has the same direction as the bow; in the other half of the string it has the contrary direction. By comparing the velocity of the bow with the velocity of the point touched by it, I found that this point of the string adheres fast to the bow and partakes in its motion during the time $a\,b$, then is torn off and jumps back to its first position during the time $b\,c$, till the bow again gets hold of it.

With these principal vibrations smaller vibrations are compounded, the nature of which I can define accurately only in the case where the bow touches a point whose distance from the nearer end of the string is $\frac{1}{5}$, $\frac{1}{6}$, $\frac{1}{7}$, &c., of its whole length, or generally $\frac{1}{m}$, if m is a whole number. Because the point where the bow is applied is not moved by any vibration belonging to the mth, $2m$th, &c., harmonic, it is quite indifferent for the motion of that point, and for the impulses exerted by the bow upon the string, whether vibrations corresponding to the mth harmonic, exist or not. Th. Young has proved that if we excite the vibrations of a string by bending it with the finger, as in the harp, or hit it with a single stroke, as in the piano, in the ensuing motion all those harmonics are wanting which have a node in the touched point. I concluded, therefore, that also the bow cannot excite those harmonics which have a node at the point where it is applied, and I found indeed, if this point is distant $\frac{1}{m}$ from the end, that the ear does not hear the mth harmonic sound, although it distinguishes very well all the other harmonics. Therefore, in the equation (1.), all those members of the sum will be wanting in which n is equal to m, or $2m$, or $3m$, &c. These members, taken together, constitute a vibration of the string with m vibrating divisions. Every such division performs the same form of vibration we have described as the principal vibration of the whole string. These small vibrations must be subtracted from the principal vibration of the whole string for getting its actual vibration. Curves constructed according to this theoretical view represent very well the really observed curves. If $m = 6$ and the observed point is distant $\frac{1}{12}$ from the other end of the string, the motion is represented in Fig. 4. Near the end of the string, where the bow is commonly applied by players, the nodes of different harmonics are very near to each other, so that the bow is nearly always at, or at least very near to, the place of a node. Striking in the middle between two nodes, I could not get

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a curve sufficiently constant for my observations. If I strike very near the end, the sound changes often between the fundamental and the

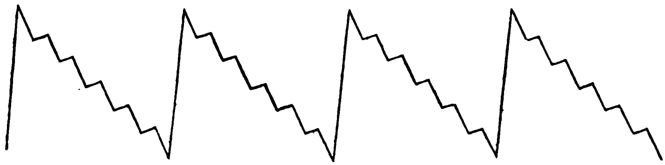

Fig. 4.

second or third harmonic, which is indicated by gradual corresponding alterations of the curve.

January 16, 1861.—*The President in the Chair.*

Mr. John Addie and Mr. John W. Stone were elected members.

Some results in Electro-Magnetism, obtained with the Balance Galvanometer. By George Blair, M.A.

Since bringing the Balance Galvanometer, along with some other apparatus, before the Society in the course of last session, the writer had made some experiments with this new galvanometer, which led to

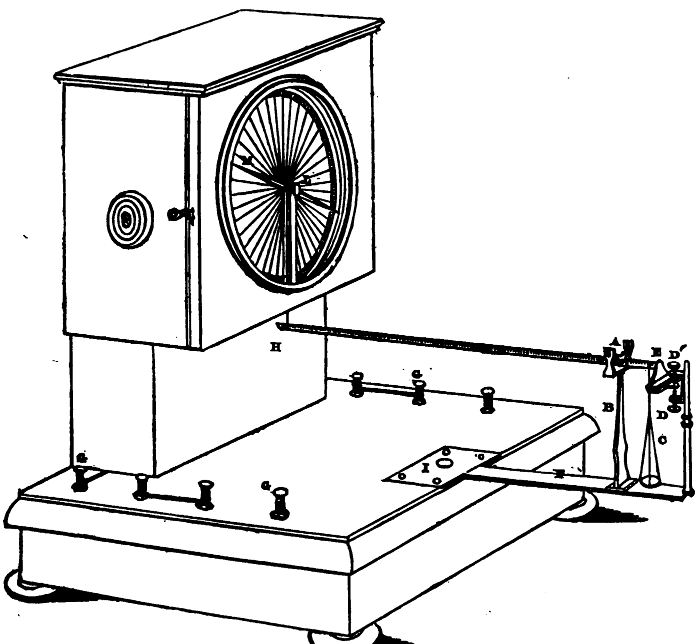

Fig. 1.

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results that he did not anticipate, and which he considered to be of sufficient importance to justify him in presenting them to the Society. The object originally aimed at in its construction was to obtain an exact measure, by weight, of the actual amount of deflective force which the current exerts upon the magnetic needle. The instrument constructed for this purpose is represented in Fig. 1. The coil consists of a total length of 1,660 feet of No. 22 copper wire, weighing rather more than 6 lbs., and divided into four parts, the ends of which are brought out and connected with their respective terminals G G, so that they can be used separately or as one coil. The needle with which the first experiments were made consisted of a small rectangular steel bar, $1\frac{1}{2}$ inch in length, rather less than $\frac{1}{4}$th of an inch in breadth, and about half the thickness of a shilling. It weighed exactly 18 grains, and, when magnetized, its lifting power was 44 grains, or nearly $2\frac{1}{2}$ times its own weight. The index M, which is 9 inches in length, weighs only 2 grains. A small brass pulley, $\frac{1}{8}$th of an inch in diameter, is fixed upon the axis between the index and the supporting screw L. The balanced lever E H consists of a thin slip of hard spring-brass, placed edgewise for strength, and tapered, for lightness, towards the end of the long arm A H. The short arm A E is loaded to act as a counterpoise, and to this arm a scale-pan C is suspended, at a distance from the fulcrum, equal to exactly $\frac{1}{10}$th of the length of the other arm. It carries also at its extremity a thin horizontal projection, which vibrates between two screw-points D, D′, and by which, with the aid of the wooden foot-screws of the instrument, the lever can be always exactly levelled when balanced. The fulcrum B is supported on a stout brass bar F, which is firmly held in its place by means of the screw I, and can be removed at pleasure. When it is desired that the needle shall have liberty to move in both directions, the extremity H of the long arm of the lever is connected with the needle by a slender wire suspended from a very fine thread, fixed to the upper part of the pulley, and carried down on both sides of it, as shown in Fig. 2. The arm A H is divided into 10 equal parts, each of which is subdivided into tenths; and, estimating the poles of the needle to be at a distance of about $\frac{1}{8}$th of its total length from the extremities, the diameter of the pulley is so adjusted that a weight of 100 grains, suspended at the distance of one of the large divisions from the

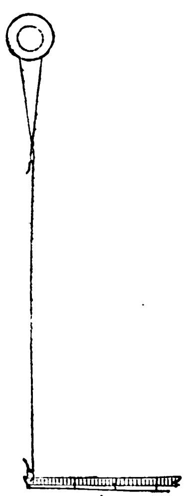

Fig. 2.

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fulcrum, acts with a force of 1 grain at the poles of the needle; suspended at division 2, it acts with a force of two grains; at 2·5, with a force of $2\frac{1}{2}$ grains, and so on.

The following table exhibits the results of the first series of experiments made with a small Grove's battery, the platinum plates of which expose only two inches of surface, and having the zinc plates immersed in a saturated solution of chloride of sodium. It is a striking characteristic of Grove's battery that it slightly increases in force after being some time in action, and it would have been preferable, therefore, to use a Daniell's, on account of its remarkable constancy, but the writer had not a sufficient number in series. The fourth column indicates the weight required to bring the index of the balance galvanometer back to zero; the fifth column expresses the same weight reduced to the force which it exerts at the poles of the needle, but increased in each case by half a grain, to compensate for the small preponderance given to the long arm of the lever in order to keep the needle vertical when not deflected by the current:—

TABLE I.

1	2	3	4	5	6
No. of Pairs.	Angles on Tangent Galvanometer.	Angles on Balance Galvanometer, without weight.	Weights required to bring the Needle to Zero.	Force at Poles of Needle, in Grains.	Ratio of Tangents Reduced.
1	4° 30′	66° —	100 grs. at 2·5	3·00	3·12
2	8 30	77° 30′	„ „ 5·5	6·00	5·96
6	29 30	87 —	1,000 grs. at 2·2	22·50	22·64
12	44 45	89 —	„ „ 4·9	49·50	39·64

It will be seen that up to six pairs, the numbers in the fifth column, expressing the force of the current in grains at the poles of the needle, vary very nearly in the same ratio as the tangents of the angles of deflection on the tangent galvanometer reduced to a comparable form in the sixth column. With twelve pairs, however, the weight required to balance the current is 49·5, or very nearly fifty grains; whereas, according to the tangent galvanometer, it should not have exceeded forty grains. Reflecting on this anomaly, the writer could only arrive at the conclusion that the needle, surrounded by a very powerful current in such a large coil, ceased to act as a permanent magnet, and was temporarily charged with a higher magnetism induced by the current itself. Subsequent experiments completely confirmed this conclusion; and he was led to examine the subject more minutely by observing that the needle, after being several times subjected to the

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action of the current from twelve pairs, appeared to have lost its permanent magnetism; for he afterwards found repeatedly that when the index was brought back by successive increments of weight to 40°, the smallest possible additional weight sent it back to zero. Before taking out the needle to ascertain this, he submitted it a second time to the action of six and twelve pairs, with the following results:—

Number of Pairs.	Current Force by Tang. Galvan.	Weights supported.
6	22·64	7·5 grains.
12	39·64	24·5 "

Whereas it will be seen, by referring to the preceding table, that originally it supported 22·50 and 49·50 grains respectively. The needle was then taken out, and was found to have almost entirely lost its magnetism. It had originally lifted forty-four grains; it was now only with the greatest precaution that it lifted two grains. But

$$7{\cdot}5 : 24{\cdot}5 = 1 : 3{\cdot}27$$

$$\text{and } (22{\cdot}64)^2 : (39{\cdot}64)^2 = 1 : 3{\cdot}06.$$

The writer had therefore little doubt that if not merely demagnetized, but formed of soft iron, the needle, when placed in a favourable position, would turn with a force proportional to the square of the current; whereas it plainly appears from Table I., that so long as its permanent magnetism is sufficient to resist the inducing action of the current, the needle is deflected with a force simply proportional to the current.

To determine this interesting question, two new needles were constructed, similar in shape and size to the former, but somewhat lighter, each weighing only 17·25 grains. The one was of steel, tempered to the hardness of glass; and was magnetized till it lifted with some difficulty forty-three grains; the other was of soft hoop-iron, well annealed. With these needles the following results were obtained from experiments conducted very carefully, and using, for greater accuracy, a single-thread suspension:—

TABLE II.

	1	2	3	4	5	6
	No. of Pairs.	Angles on Tangent Galvanometer.	Tangents to Rad. 1.	Deflective Force at Poles of Needle, in grains.	Ratio of Tangents.	Ratio of Squares of Tangents.
With Magnetized Steel Needle.	3	17° 40′	0·318	11·5	11·5	11·4
	6	31 20	0·609	22·0	22·0	42·1
	9	41 0	0·869	32·5	31·5	85·8
	12	47 0	1·072	43·5	38·8	130·6
With Needle of Soft Iron.	3	17° 40′	0·318	6·0	6·0	6·0
	6	31 0	0·601	20·5	11·4	21·5
	9	40 20	0·849	40·0	16·1	42·9
	12	47 0	1·072	57·0	20·4	68·4

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A glance at the above table will show that, with the permanently magnetized needle, the numbers in column 4, expressing the deflective force of the current in grains, are very nearly proportional to the numbers in column 5, expressing the *simple ratio of the tangents* or *quantities of current*; whereas with the soft iron needle they are nearly proportional to the *squares of the same quantities*, reduced to a comparable form in column six. In both cases the only marked deviation coincides with the powerful current from 12 elements of the battery, in which case the steel needle, evidently acting under the superadded influence of induced temporary magnetism, is deflected with a force which exceeds the estimated amount by 4·7 grains, whereas the soft iron needle, under the same current force, falls short of the calculated amount by 11·4 grains. The last effect is probably attributable to the fact that, as the needle approaches saturation, the law of the squares gradually merges into the law of simple proportion. The writer regrets that he had not at command sufficient battery power to put this point to the test of decisive experiments, but hopes to do so shortly with a Daniell battery of 50 or 100 elements. In the meantime the results above given, having been arrived at with great care, and amply confirmed by experiments several times repeated, appear to establish very conclusively the following principles:—

1. A permanently magnetized steel needle, suspended in the middle of a galvanometer coil, is deflected with a force simply proportional to the quantity of current transmitted, so long as the current force which acts upon it is not sufficient to impart temporarily a higher magnetism than that which it permanently possesses. Beyond this point, the deflective force exerted on the magnetized steel needle increases in a somewhat higher ratio than the current, and therefore the accuracy of any form of galvanometer can be trusted only within certain limits of current force and of length and proximity of coil.

2. A pure soft iron needle, suspended at an angle of about 40° to the direction of the current (the angle varying according to the shape of the needle), is deflected with a force which, within certain limits of current power, is very exactly proportional to the squares of the quantities of current. Beyond these limits the deflective force exerted on the needle increases in some constantly diminishing ratio lower than that of the squares of the current.

3. The action of the current in deflecting a magnetic needle is precisely the same action, and follows the same law, as that which it exerts in magnetizing a bar of soft iron. The amount of magnetism actually imparted to a bar or needle of soft iron is directly proportional to the quantity of current; for the force with which a soft iron needle is deflected under different currents is not proportional to its tempo-

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rary magnetism in each case, but to the product of its magnetism multiplied by the force of the current. By increasing the force of the current, two effects are produced ; in the *first* place, the magnetism of the needle is increased in the same proportion ; and *secondly*, the increased current acting upon this increased magnetism deflects the needle with a force proportional to the product of the two, or in other words, proportional to the square of the actual quantity of current.

It only remains to add the results of two series of experiments, shows ing the very striking difference between the defective forces exerted upon the two needles at different angles of inclination. Table III. shows the increasing weights required to balance the needles at angles successively diminished by 10°; Table IV. exhibits the effect produced by successive additions of weights, equivalent to a force of ten grains acting at the poles of the needles. In both cases the battery power employed was twelve small Groves, but the current declined, in the course of the experiments, from 47° to 45° on the tangent galvanometer, which accounts for the fact that the maximum weights supported are less than in the earlier experiments recorded in Table II. In working out Table III., the weight employed (1,000 grains) was simply advanced along the lever, and its reduced amount at the poles of the needle noted, when the index, in gradually retreating, pointed to the successive angles specified. The results in Table IV. were obtained by moving the weight from one to another of the successive divisions, marked 1, 2, 3, &c., on the lever; and the differences of the angles vary, as might be expected, in nearly the reverse order of the differences of weights in Table III :—

TABLE III.

	Angles on Balance Galvanometer.	Weights reduced to Force at Needle, in grains.	Differences of successive Weights.
With Magnetized Steel Needle.	9	0·0	6·5
	80	6·5	9·0
	70	15·5	7·5
	60	23·0	7·0
	50	30·0	5·0
	40	35·0	4·4
	30	39·4	2·1
	20	41·5	0·5
	10	42·0	
With Soft Iron Needle.	90°	0·0	15·5
	80	15·5	14·0
	70	29·5	11·0
	60	40·5	9·5
	50	50·0	3·0
	40	53·0	

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TABLE IV.

	Weights reduced to Force at Needle, in grains.	Angles on Balance Galvanometer.	Differences of successive Angles.
With Magnetized Steel Needle.	0·0	90° 0′	14° 30′
	10·0	75 30	12 30
	20·0	63 0	14 30
	30·0	4 30	22 30
	40·0	26 0	
	41·5	0 0	
With Soft Iron Needle.	0·0	90° 0′	6° 0′
	10·0	84 0	7 30
	20·0	76 30	8 10
	30·0	68 20	8 10
	40·0	59 10	12 0
	50·0	47 10	
	52·0	0 0	

It will be observed from Table III. that a very small weight was sufficient to throw back the steel needle to 80°, and that, on the contrary, it is from 90° to 70° that the soft iron needle sustains itself with comparatively the greatest power, requiring very nearly double the weight which suffices for the steel needle to balance it at the latter angle. When reduced to 40°, however, the smallest possible additional weight throws back the iron needle to zero, and in every case it was necessary to move it aside with the finger to nearly that angle, before it would exhibit the slightest action under the influence of the current, or, in other words, any perceptible trace of *longitudinal* magnetization. In fact, being laterally magnetized when hanging in a vertical position, it necessarily offered a certain resistance to deflection.

On taking out the steel needle after these experiments, it was found to have retained its original magnetism unimpaired.

The tangent galvanometer by which the force of the current was determined in the preceding experiments, and which the writer had also the honour of submitting to the Society last session, is represented in Fig. 3. It is a very convenient modification of Gaugain's instrument, described in the *Annales de Chimie*, vol. xli., 1854. The circular frame A, containing a variety of coils of different lengths and sizes of covered wire, is 9·6 inches in external diameter, so that when the instrument is in use, the divided circle must be drawn out till its centre is 2·4 inches in front of the coil or coils through which the current is to be sent. To facilitate this operation, the horizontal bar D, upon which the disc slides, has the proper distances for each coil marked upon it, and these are successively exposed to view at the back of the instrument, in proportion as the disc is drawn smoothly forward by means of the

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handle C. The needle is only one inch in length, but carries parallel to itself a fine filament of glass for an index ;* it is suspended by a silk fibre, and is raised so as to hang freely within its glass shade by turn-

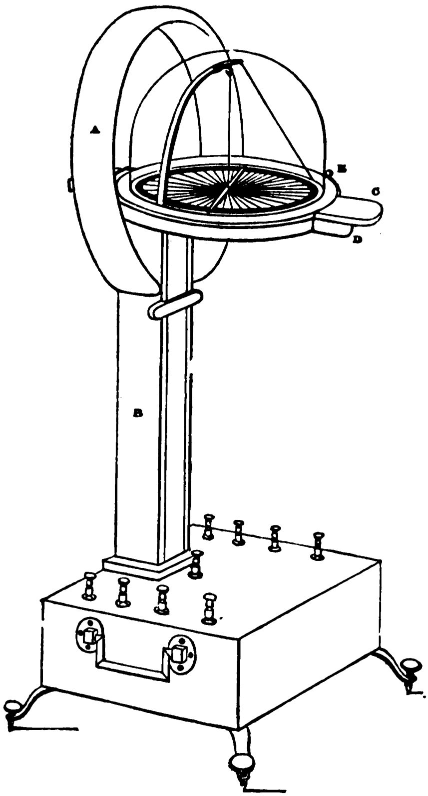

Fig. 3.

ing the pin E. The ends of the coils are carried down through the hollow pillar B, and by connecting the electrodes of the battery with the proper terminals, the current can be sent through one or more of the coils. It can be sent through one convolution of No. 16, through 203 convolutions of No. 34, or any other of the intermediate lengths and sizes of wire ; and in this way the resistance and the force exerted by the current upon the needle can be very exactly adapted to the character of the battery, or other rheomotor employed.

* The thickness of the index is grossly exaggerated in the figure: it ought to be as fine as a hair, and short in one arm.

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January 30, 1861.—PROFESSOR W. J. MACQUORN RANKINE, *the President, in the Chair.*

The Hon. Peter Clouston, Lord Provost of the City; Mr. James Murray, Monkland; Mr. George D. Charles, Royal Bank; Mr. John W. Law, Phœnix Iron Works; and Mr. James Walker, Crawford Street Chemical Works, were elected members of the Society.

Remarks upon the Fall of Rain in the Districts Supplying Glasgow with Water. By JAMES M. GALE, C.E.

IN addition to the interest which observations upon the amount of rain-fall in any district have in a meteorological sense, they have a further interest to the engineer engaged in designing or constructing works for irrigation or water-power, or for the supply of water to towns. This information is in fact quite indispensable; for upon it depends, in a great measure, the extent of country or drainage area required to yield a given quantity of water, and also the magnitude of the works necessary for impounding or storing the water.

These observations are considered so important, that few water-works, deriving their supply from surface collection, are without their rain gauges; and it is to the observations made in the drainage areas of the Loch Katrine and Gorbals water-works, that I beg to draw your attention for a few minutes, believing that they will not be without interest to the members of this Society. I do not at present intend to speak of the quantities of water these districts yield for the purposes of the water-works, as that question was fully discussed before the construction of the Loch Katrine water-works was commenced.

The Gorbals district lies south from Glasgow at a distance of about eight miles. Two rain gauges were erected by my late brother, the Engineer for the works, and their registration kept since 1849. Their respective elevations are 280 and 310 feet above the sea. In 1854, additional gauges were set down at elevations of 550 and 700 feet. The result of the gaugings from 1849 to 1853 inclusive is given in Table No. 1 at the end of this paper. The quantities given are the averages of the two gauges first referred to.

The Loch Katrine district, I need scarcely remind you, lies north-west from Glasgow, at a distance of about thirty-four miles, on the borders of the Perthshire Highlands. Six rain gauges were placed in this district in 1853, under the instructions of Mr. Bateman, at elevations varying from 60 to 1,800 feet above the sea.

The gauges employed are cylindrical vessels of sheet copper, those at the Gorbals being 12 inches in diameter, and about 3 feet deep, and those in the Loch Katrine district, 8 inches in diameter, and 4 feet deep;

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and all are sunk into the ground to within 2 or 3 inches of the top. The water in all the gauges is covered by a copper float of a size just sufficient to admit of its rising freely, as the rain is collected inside. The object of this float is to prevent evaporation from the surface of the water inside the gauge, which otherwise would seriously affect the results. The tops are funnel shaped, with a hole in the middle to admit of the gauge rod working freely through it. In the case of the Gorbals gauges the rods are attached to the floats, but in the Loch Katrine gauges the rods are detached from the floats, and are passed down from the hole in the bottom of the funnel, on to the top of the float, when an observation is to be made. This latter arrangement of the gauge rod is undoubtedly the one least liable to error; for, in the case of attached rods, rain, when accompanied by high wind, may be caught by the rod, if projecting much above the top of the gauge, which would otherwise have passed over it. The Gorbals gauges are, however, regularly emptied once a-month, and, except in cases when rain propelled by a strong wind reaches the ground at a less angle than 45°, there can be no error till the rod rises half the diameter of the gauge, or 6 inches above the top. There are not many months in the year when the rain-fall in the Gorbals district exceeds 6 inches, and the possible error from the attached rods can only exist for a few days, at the latter end of those months.

The whole of the gaugings are given in an extended form in Table No. 2 at the end of this paper.

I have made a diagram showing the rain-fall in the Gorbals district, as far as the observations go, from 1855 to 1859, drawn to scale. The gauging at the Black Loch was discontinued in 1858 and 1859, but it has been recommenced. I have introduced, for the object of comparison, the results obtained by Mr. Gardner from a rain gauge which has been kept for many years at Ibroxholm, two miles west of Glasgow, and at an elevation of about twenty feet above the sea. In the middle of 1857 this gauge was moved to Pollokshields, where the elevation is about fifty feet above the sea. The whole country lying between Glasgow and the furthest end of the Gorbals district is comparatively regular in inclinations; it is not broken up by any mountain masses to disturb the atmospheric currents, and the series of gaugings afford a very striking instance of the well-known and very general law, that an increased elevation gives an increased rain-fall. The regularity of this increase is very striking in 1855, 1857, and 1858, where the deviation of any of the gaugings from a straight line joining the two extremes of rain-fall is very slight. Notwithstanding this regularity of increase in fall found in the Gorbals district, it is not to be supposed that the same regularity

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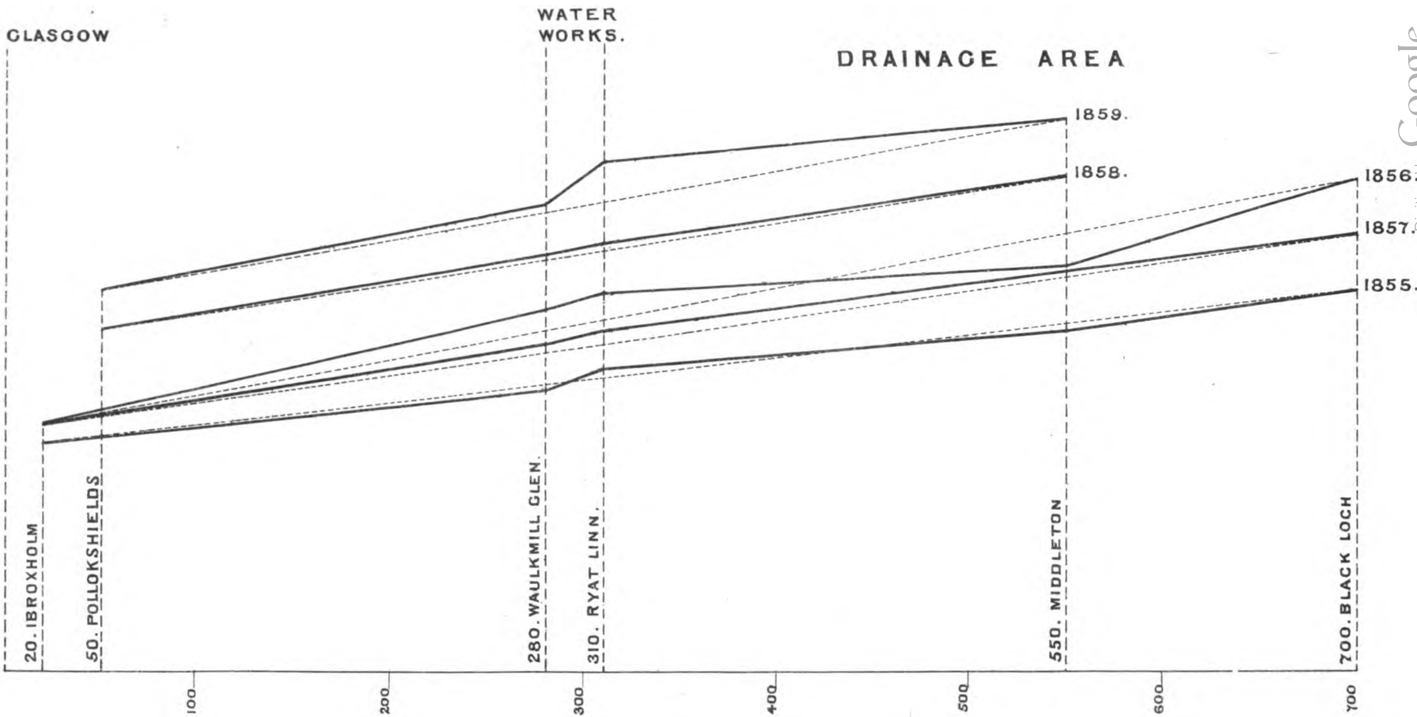
DIAGRAM OF RAINFALL IN CORBALS DISTRICT,

1855 TO 1859.



Horizontal Scale 1 in. = 100 feet. Vertical Scale 1 in. = 20 ins.

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will be found in all districts. The physical conformation of any given piece of country affects the rain-fall to such an extent as to make it impossible to apply to one district the results which have been found in another.

The gaugings in the Perthshire Highlands show this in a marked degree. The district is quite the opposite in physical features to the Gorbals. It is of the wildest and most rugged description, the mountain peaks shooting upwards, in many cases, from 1,500 to 3,000 feet above the valleys; the sides of the hills are rocky and precipitous; the valleys are very irregular in direction, sometimes running obliquely, and at others at right angles to each other. And the wind is swayed hither and thither as the mountains obstruct, or the glens induce, a passage. Of two gauges, each of which is at an elevation of 1,800 feet above the sea, the one at the head of the Duchray valley, the source of the river Forth, and on the eastern slope of Benlomond, shows upwards of a half more rain than the other, which is placed on the western slope of Benledi. This difference must be sought for from other causes than that of elevation.

The greater portion of the rain which falls on the west coast of Britain comes from the west and south-west; and it has been long established, that more rain falls upon the eastern slope of a range of hills than upon the western. It has been observed that the wind sweeps the rain-clouds with great velocity up the western slope, but when over the top they lose their momentum and deposit their rains. These two gauges, it must be observed, however, are not upon opposite sides of the same range of hills, for between the Benledi gauge and the one on Benlomond we have the Duchray valley, and the valleys of Loch Chon and Loch Katrine, with the mass of Benvenue between the latter.

The Bridge of Turk gauge may be said to be in a position similar to the Benledi gauge, and the results are much the same. The Glengyle gauge, though at an elevation of only 380 feet, shows as much rain as the Benlomond gauge, but it is in a precisely similar position: it is at the eastern base of Benhonie, which has comparatively open ground to the south-west, as far as the Cobbler. The gauge between Loch Ard and Loch Katrine has also a rising ground to the west; while at Aberfoyle, at an elevation of 60 feet above the sea, at the eastern end of a valley some miles in length, in which the clouds have had time to deposit their rain, the fall is the least in the district, being only one-half of what is got at the Benlomond and Glengyle gauges.

The result of the gaugings made on the Shaws Water district, near Greenock, also show the marked effect the configuration of the country has upon the amount of rain-fall. These gauges, of which there are five, have been kept by Mr. Morrison, the manager of the works, since 1835.

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They are placed at elevations varying from 480 to 800 feet above the sea, and the average of the twenty-five years' gaugings is as follows :—

Elevation,	480,	Everton Gardens,	61·50 Inches.
„	540,	No. 4,	56·75 —
„	560,	„ 2,	64·63 —
„	600,	„ 1,	58·52 —
„	800,	„ 3,	55·93 —

Here the highest gauge gives the least rain, while the greatest is obtained at an elevation of 560 feet. I have not visited all these gauges myself; but I am informed by Mr. Morrison that the gauge which gives the greatest fall is at the base of a hill sloping towards the north-east. The Everton gauge is very much in the same position, while the others are more or less exposed to the west. The town of Greenock itself would, I have no doubt, from its position, give a large amount of rain-fall, but I have no gaugings to show.

In a hilly country the greatest care ought to be exercised by the engineer in placing his rain gauges, when it is sought to arrive at an average rain-fall over any given district. The more elevated and precipitous the hills are, the greater are the variations in fall at places comparatively near each other. I am of opinion that points of extreme fall in such districts can be assumed with much greater certainty than points of mean fall, and that the truest method of discovering the average, is to set about finding the extremes. In the beginning of this year I planted four additional gauges in the Loch Katrine district, and their results should help materially in arriving at a correct mean.

TABLE No. I.

RAIN-FALL AT THE GORBALS WATER WORKS, FROM 1849 TO 1853 INCLUSIVE.

Average of the two Rain Gauges marked No. 1 *and No.* 2 *in Table No. II.*
Average Height of Gauges 295 *feet above the Sea.*

	1849.	1850.	1851.	1852.	1853.
	Inches.	Inches.	Inches.	Inches.	Inches.
January,	10·40	3·15	7·70	10·00	8·30
February,	4·20	9·20	5·60	6·05	1·45
March,	1·95	0·80	5·55	1·02	1·35
April,	1·65	3·60	2·15	0·70	1·90
May,	3·80	2·65	0·70	3·55	0·50
June,	2·05	2·30	4·30	4·35	3·60
July,	5·10	3·00	4·32	7·65	4·90
August,	3·00	4·55	5·20	4·47	4·22
September,	2·10	2·60	1·10	1·00	2·65
October,	3·90	3·35	4·12	2·38	6·15
November,	7·50	4·90	1·50	7·35	4·45
December,	1·90	6·10	2·47	11·90	0·50
	47·55	46·20	44·71	60·42	39·97

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TABLE No. II.

RAIN-FALL IN THE LOCH KATRINE AND GORBALS DISTRICTS.

From 1854 to 1860 Inclusive.

Date.	LOCH KATRINE DISTRICT.						GLASGOW.	GORBALS DISTRICT.			
	Elevation 270 feet.	Elevation 1800 feet.	Elevation 380 feet.	Elevation 60 feet.	Elevation 1500 feet.	Elevation 1800 feet.	Elevation 20 feet.	Elevation 280 feet.	Elevation 310 feet.	Elevation 550 feet.	Elevation 700 feet.
	At Bridge of Turk.	Between Glen Finglas and Benledi.	At Glengyle, head of Loch Katrine.	At the Inn at Aberfoyle.	On Hills between Loch Ard and Loch Katrine. Ledard.	Benlomond, head of Duchray Valley.	At Ibroxholm. Mr. Gardner.	Waulk Glen Reservoir. No. 2.	Ryat Linn Reservoir. No. 1.	At Middleton.	At [illegible] Loch.
1854.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Jan....	8·5	6·6	12·0	6·8	7·1	9·1	4·73	5·00	5·00	...	...
Feb....	4·4	2·2	9·5	4·3	3·6	8·7	2·77	3·80	3·65	...	6·05
March	4·1	3·3	7·4	3·9	4·1	8·0	1·75	3·35	3·15	...	4·85
April..	1·2	0·7	2·6	0·7	1·7	3·0	0·62	1·17	0·97	...	1·70
May...	5·2	6·0	8·8	3·7	5·6	7·6	4·60	4·90	4·60	...	5·20
June...	6·4	5·2	9·4	6·4	8·1	10·3	3·48	4·60	4·30	...	7·00
July...	6·5	2·8	4·7	5·1	6·6	7·5	2·98	2·40	2·40	3·06	3·25
Aug...	4·4	1·5	6·7	4·0	5·6	6·5	1·66	2·50	2·46	3·30	3·90
Sept...	3·3	7·3	6·1	2·2	1·8	6·8	2·02	3·10	2·90	3·80	4·10
Oct....	8·4	9·3	12·2	6·3	11·3	17·3	3·93	5·30	4·70	6·50	7·00
Nov...	2·7	5·4	5·7	3·9	3·1	4·5	1·85	2·35	2·10	3·78	3·10
Dec....	9·4	11·9	18·2	8·8	8·5	19·7	5·32	7·45	7·05	9·20	11·40
	64·5	61·9	103·3	56·1	67·1	109·0	35·71	45·92	43·28	29·64	57·55
1855.											
Jan....	1·0	4·7	1·8	1·0	1·7	3·3	0·36	1·25	1·25	1·40	1·65
Feb....	0·2	0·2	1·2	0·2	1·2	1·6	0·60	0·55	0·55	3·70 (Feb. and March)	1·50
March	4·4	3·7	7·5	4·5	Gauge kept very irregularly, and supposed to have been interfered with.	8·0	1·52	2·90	3·00		2·70
April..	2·5	5·2	6·1	3·0		7·5	1·26	1·90	2·10	2·30	3·05
May...	1·6	3·9	3·2	2·8		3·4	1·48	1·85	2·00	2·30	2·10
June...	3·2	1·0	3·7	0·9		3·5	2·88	2·20	2·30	2·70	3·30
July...	4·0	4·4	3·2	4·2		5·1	3·20	2·88	2·93	3·16	4·00
Aug...	6·2	11·4	10·3	3·9		9·8	4·35	4·85	5·05	5·75	6·50
Sept...	1·3	5·0	3·0	1·0		4·9	0·73	1·25	1·40	1·75	2·30
Oct....	7·7	5·3	13·5	6·9		13·8	4·06	5·30	5·70	7·30	7·20
Nov...	1·8	6·8	3·1	1·4		4·2	0·97	1·50	1·60	1·75	2·00
Dec....	5·1	4·5	8·9	4·8	5·2	4·8	2·35	3·50	3·80	3·40	3·60
	39·0	56·1	65·5	34·6	...	69·9	23·76	29·93	31·68	35·50	39·90
1856.											
Jan....	3·5	Gauging discontinued.	4·7	1·4	4·2	4·0	2·00	2·70	2·80	2·85	3·00
Feb....	7·7		10·8	7·3	9·0	13·2	3·31	5·00	5·30	4·60	6·20
March	0·1		0·7	0·2	0·1	0·9	0·05	0·00	0·00	0·00	0·00
April..	2·7		4·7	2·9	3·5	4·0	1·46	2·00	2·15	2·15	2·00
May...	3·2		4·6	3·8	4·5	5·7	2·80	3·35	3·35	3·75	4·20
June...	5·6		9·9	4·7	12·3	10·0	3·40	5·70	5·75	6·30	7·95
July...	3·8		9·1	3·1	6·2	4·5	1·80	2·75	2·80	3·25	3·90
Aug...	5·2		6·3	3·9	9·7	8·8	2·40	4·50	4·55	5·30	5·40
Sept...	4·4		5·5	3·7	5·6	6·5	2·40	3·10	3·10	3·10	4·20
Oct....	3·9		7·2	1·8	6·2	6·9	1·20	1·85	1·85	2·15	3·00
Nov...	1·5		4·4	0·1	3·9	6·8	0·80	1·25	1·55	2·50	2·60
Dec....	6·7		11·4	3·8	8·9	9·7	3·85	5·80	6·55	6·30	9·05
	48·3	...	79·3	36·7	74·1	81·0	25·47	38·00	39·75	42·25	51·50

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TABLE II.—*continued.*

Date.	LOCH KATRINE DISTRICT.						GLASGOW.	GORBALS DISTRICT.			
	Elevation 270 feet.	Elevation 1800 feet.	Elevation 380 feet.	Elevation 60 feet.	Elevation 1500 feet.	Elevation 1800 feet.	Elevation 20 feet.	Elevation 280 feet.	Elevation 310 feet.	Elevation 550 feet.	Elevation 700 feet.
	At Bridge of Turk.	Between Glen Finglas and Benledi.	At Glengyle, head of Loch Katrine.	At the Inn at Aberfoyle.	On Hills between Loch Ard and Loch Katrine. Ledard.	Benlomond, head of Duchray Valley.	At Ibroxholm. Mr. Gardner.	Waulk Glen Reservoir. No. 2.	Ryat Linn Reservoir. No. 1.	At Middleton.	At Black Loch.
1857.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Jan....	6·3	3·2	12·0	1·2	4·9	7·5	1·65	3·30	3·84	3·80	4·95
Feb....	4·6	3·3	10·5	8·5	6·5	7·7	0·90	2·25	2·60	2·75	3·10
March	5·3	3·1	7·3	3·4	4·9	6·0	1·95	2·75	3·05	3·60	3·50
April..	3·7	4·6	7·8	4·6	5·2	5·4	1·70	1·70	1·85	2·20	2·65
May...	3·3	3·8	6·0	4·8	5·9	5·9	1·55	1·90	1·90	1·95	2·05
June...	2·5	3·8	4·0	1·4	3·8	3·9	2·85	3·35	3·10	3·95	4·00
July...	3·1	3·5	5·2	1·0	4·6	5·1	1·22	1·50	1·55	2·45	2·95
Aug...	2·9	4·4	4·2	3·1	4·7	4·9	1·40	1·45	1·45	1·90	1·50
Sept...	4·2	3·7	4·0	4·4	5·4	6·4	2·96	2·55	2·60	3·30	3·00
Oct....	5·3	5·6	7·7	5·6	7·4	8·8	2·70	3·60	3·80	4·75	5·80
Nov..	3·9	3·8	5·9	2·7	8·0	5·9	2·54	3·20	3·30	3·80	4·20
Dec....	9·7	5·5	17·0	6·9	12·9	18·0	3·94	6·70	6·80	7·25	8·00
	54·8	48·3	91·6	47·6	74·2	85·5	25·36	34·25	35·84	41·70	45·70
1858.											
Jan....	7·2	4·7	9·0	5·5	12·6	12·4	3·26	4·75	5·00	6·10	5·80
Feb ...	0·9	0·0	2·5	1·1	1·8	3·3	1·30	2·00	2·15	1·80	1·10
March	2·2	0·8	3·3	1·1	2·9	1·9	1·46	1·95	1·95	} 5·70	{4·20
April..	3·6	3·5	5·5	0·6	5·6	3·9	2·12	2·38	2·45		{3·15
May...	5·5	5·5	8·2	2·4	9·0	7·5	3·58	5·25	5·35	5·70	7·00
June...	4·4	4·5	6·4	4·4	7·2	6·6	3·79	3·20	3·20	3·20	3·70
July...	6·9	8·5	7·8	2·8	9·3	7·6	5·39	4·95	5·05	5·30	5·50
Aug...	4·6	4·9	7·3	2·1	8·9	7·4	2·09	2·45	2·50	3·40	4·50
Sept...	5·3	5·5	8·2	3·9	9·0	10·2	2·88	3·55	3·65	4·80	Gauging discontinued
Oct....	6·6	6·6	9·7	6·7	12·2	11·0	5·09	6·45	6·75	7·55	
Nov...	3·3	3·3	3·8	2·5	6·4	4·2	1·63	1·85	1·85	2·60	
Dec....	9·7	7·4	13·1	8·4	12·2	14·4	3·08	4·55	4·65	5·55	
	60·2	55·2	84·8	41·5	97·1	90·4	35·67	43·33	44·55	51·70	34·95
1859.											
Jan....	10·1	6·1	14·3	8·5	10·0	14·0	4·43	6·50	7·05	6·00	Gauging discontinued.
Feb....	6·4	3·8	11·0	5·2	7·6	11·0	5·23	6·25	7·60	5·50	
March	9·2	4·6	14·5	5·9	11·2	14·9	5·60	6·65	7·75	9·70	
April..	4·9	3·1	5·5	3·7	5·0	3·9	3·90	4·20	4·50	5·25	
May...	0·4	0·5	0·3	0·3	0·7	0·7	0·52	0·35	0·40	0·50	
June...	1·3	0·5	2·9	1·4	3·2	3·5	1·36	1·65	1·80	2·05	
July...	2·0	3·6	4·6	2·5	6·1	5·5	1·98	3·00	3·00	4·00	
Aug...	5·4	6·1	7·9	5·6	10·1	9·8	2·89	4·15	4·30	4·55	
Sept...	9·4	8·4	10·5	6·5	13·2	13·2	3·88	4·65	4·90	6·70	
Oct....	4·4	3·6	5·6	3·5	6·6	5·2	3·46	3·70	3·85	3·60	
Nov...	6·8	5·5	9·0	5·5	6·3	7·5	3·04	3·85	3·85	4·50	
Dec....	4·9	2·2	7·6	4·0	5·3	2·6	3·50	3·75	4·35	5·30	
	65·2	48·0	93·7	52·6	85·3	91·8	39·79	48·70	53·35	57·65	...

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TABLE II.—*continued.*

Date.	LOCH KATRINE DISTRICT.						GLASGOW.	GORBALS DISTRICT.			
	Elevation 270 feet.	Elevation 1800 feet.	Elevation 380 feet.	Elevation 60 feet.	Elevation 500 feet.	Elevation 1800 feet.	Elevation 20 feet.	Elevation 280 feet.	Elevation 310 feet.	Elevation 550 feet.	Elevation 700 feet.
	At Bridge of Turk.	Between Glen Finglas and Benledi.	At Glengyle, head of Loch Katrine.	At the Inn at Aberfoyle.	On Hills between Loch Ard and Loch Katrine. Ledard.	Benlomond, head of Duchray Valley.	At Ibroxholm. Mr. Gardner.	Waulk Glen Reservoir. No. 2.	Ryat Linn Reservoir. No. 1.	At Middleton.	At Black Loch.
1860.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Jan....	8·5	6·2	10·5	5·2	3·4	9·5	5·09	5·55	5·95	5·65	
Feb....	4·1	2·4	14·5	1·8	2·1	0·0	3·21	4·55	4·70	4·40	Gauging discontinued.
March	6·2	1·1	11·2	4·4	1·5	12·7	7·94	3·80	4·50	4·50	
April..	1·9	3·1	2·8	0·2	2·0	2·0	1·01	1·30	1·40	1·35	
May...	3·7	3·2	6·2	3·4	5·5	8·0	...	2·55	2·70	3·55	
June...	8·1	8·5	9·4	6·8	14·0	11·0	4·78	3·95	3·95	4·40	
July...	3·2	5·7	2·1	0·4	4·0	4·4	2·13	2·35	2·40	2·72	
Aug...	5·2	6·2	7·5	3·8	9·4	10·4	3·54	3·35	3·55	4·05	
Sept...	3·3	2·3	5·8	3·2	6·4	5·6	1·50	1·90	2·00	2·25	
Oct....	8·0	5·7	14·1	6·2	10·5	14·7	4·68	6·00	6·10	6·82	
Nov...	2·9	2·7	4·3	2·1	6·4	3·6	1·28	1·55	1·65	2·73	
Dec....	4·7	6·7	5·8	2·9	8·3	1·6	2·80	2·60	2·60	2·30	
	59·8	53·8	94·2	40·4	73·5	83·5	...	39·45	41·50	44·72	...
	56·0	53·9	87·5	44·2	78·5	87·3	30·96	39·94	41·42	45·59	45·70

Report of the Temperature and Rain-fall, &c., of the Year 1860, *observed at Cessnock Park.* By ROBERT HART.

As the weather of last year was of a variable character, perhaps a review of it may be worth the attention of the Society. With that view I have compared it with a few former years, and I find that the frost set in this winter earlier than it has done for the last six years; and the cold has been more intense, by about seventeen degrees, than the coldest of these last six years. In the following list are the dates of the first frosty night in each winter, and the lowest degree of cold observed, and also the date of the last frosty night of the season:—

The Year.	The First Frost	The Lowest Temperature and Date.	The last Frosty Night.
1854	November 9, 28°	7° on February 17	May 18, 1855.
1855	October 11, 32 ...	10·5 on December 13	May 4, 1856.
1856	November 11, 31	8 on December 12	May 1, 1857.
1857	October 23, 32	15 on March 15	May 6, 1858.
1858	October 19, 22	15 on November 23	May 6, 1859.
1859	October 20, 25	5 on December 19	May 6, 1860.
1860	September 10, 32.	This lasted only one night;	

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but it was again frost on 24th, continued four nights; and again on October 11th, &c., till the last long frost, which lasted from December 13, till we may say 20th January, 1861. The greatest cold was on the night of the 25th December, as the following will show:—

On the 22d December	it was		10°	above zero of Fahrenheit's scale.	
„ 23	„	+	15	Ditto.	
„ 24	„	—	5	below zero, or 37° below the freezing of water.	
„ 25	„	—	8	Ditto,	or 40° Ditto.
„ 26	„	—	6	Ditto.	
„ 27	„	—	5	Ditto.	
„ 28	„	+	10	above zero, or 22° below the freezing of water.	
„ 29	„	+	10	Ditto.	
„ 30	„	+	28	Ditto.	
„ 31	„	+	32	Ditto,	or at the freezing point.

THE MEAN HEAT OF EACH MONTH IN THE SHADE, MEAN COLD, AND MEAN OF BOTH.

Greatest Heat observed during the Month.		Mean Heat of the Month.	Mean Cold of the Month.	Mean of both Heat and Cold.
January,............	49°	42°	31·2°	36·6°
February,...........	49	38·6	25·8	32·2
March,...............	50	45	30·5	37·75
April,................	58	54	32	43
May, ...	70	62·7	38·5	56·6
June, ...	67	60·2	39	49·6
July,..................	76	66·5	49·3	57·9
August, ...	67	61·2	48·6	54·94
September,..........	70	58	36·3	47·15
October, ...	58	51·5	33·6	42·5
November, ...	50	42·2	31·1	36·6
December, ...	49	35·2	25·9	30·5

RAIN-FALL MONTHLY DURING THE YEAR 1860, AT CESSNOCK PARK, GOVAN ROAD.

	Number of Days on which Rain fell.	Quantity of Rain in inches.	Kind of Weather during each Month.
January,...	20 days	5·10	9 good days, rain every second day.
February,	12 „ snow 1	3·3	11 good, the rest stormy.
March, ...	18 „ snow 2	3·63	14 good, much haze and frost.
April,......	6 „	1·4	The last half of month good.
May,.......	9 „ hail on 3	1·86	Thunder on two days, 15 good.
June,.......	20 „	3·99	Thunder two days, the 15 to 25 good.
July, ...	10 „	2·0	First part fine, the last showery.
August, ...	21 „	3·40	Few good days, thunder, with much rain.
September,	10 „	1·26	Rather a good month.
October,...	21 „	3·39	Stormy and unsettled.
November,	9 „ snow 3	1·35	First part good, last changeable.
December,	9 „ snow 3	2·87	First haze and wet, last part very keen frost and snow.

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Although there were many rainy days in 1860, yet it was under the average quantity of rain by two and a-half inches.

The year 1859 was thought rather a dry one, yet it was above the average by more than four and a-half inches.

MR. HART inquired whether the rain gauges described by Mr. Gale were placed above the surface of the ground? His own gauge was raised four feet above the surface; because he found that when it was close to the ground, the sparks of rain-drops falling in its immediate neighbourhood were also conveyed into the gauge by currents of the wind, so that the gauge received more than its share. The effect produced by the sparking of rain might be seen on the pavement during a heavy shower, when the surface, to a height of several inches, presented a thick atmosphere of moisture, occasioned by the rebounding of the descending drops.

MR. GALE replied, that rain falling upon a hard surface undoubtedly produced the effect described by Mr. Hart; but the gauges referred to, and which were placed a few inches above the surface of the ground, were surrounded by grass kept closely cut, so as not to obstruct the passage of the rain into the gauge, while the surrounding soft surface prevented the undue entrance of rain from sparking.

DR. MATHIE HAMILTON concurred with Mr. Hart in the opinion, that an uncertain result might be produced by gauges placed too close to the surface of the ground.

DR. ALLEN THOMSON stated, as the result of his own observations, that when a rain gauge was constructed in the position of those described by Mr. Gale, at a height of two or three inches above the level of short-cut grass, the sparks caused by the heaviest fall of rain did not interfere in the slightest degree with the faithful indication of the instrument. He could quite understand how on a hard surface the sparking might produce an erroneous result; but by surrounding the gauge with short-cut grass, any such tendency to error was entirely obviated. It was also observed by the late Professor Fleming that small gauges gave the same result as large gauges. In high-placed gauges the currents of air upwards interfere with the entrance of the rain, and give a lower indication than when they are situated near the surface of the ground. The great object is to place the gauge as low as possible, always taking care to guard against any undue entrance of rain from sparking. He should like to know from Mr. Gale how far his observations or information would lead to the belief of the general prevalence of the phenomenon he had mentioned, that a greater quantity of rain falls on the east than on the west side of a range of hills? Had

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it been established by observation, that this result applied generally throughout Scotland, and in other parts of the kingdom?

Mr. Gale said that it had been observed in Lancashire and the north of Yorkshire, where more rain was found to fall on the eastern than on the western slopes of the hills. Observations made in Cumberland also established the same fact. In the latter district, the greatest amount of rain-fall was found to take place at a height of 2,000 feet.

The President could confirm the observation of Mr. Gale, that there is a greater fall of rain on the eastern than on the western slopes of hills. He had occasion, about the year 1846, to make a series of observations on the Pentland Hills, with a view to obtaining a new supply of water for Edinburgh, when he found, as the result of numerous observations made by himself and others, that the rain-fall on the eastern was much in excess of the quantity on the western slopes of the range. Another principle that seemed to be established by the observations at that time was to a great extent confirmed by those made by Mr. Gale, namely, that the quantity of rain does not depend so much on the absolute elevation in which the gauge is placed, as upon its nearness to the summits of the neighbouring hills, where the condensation of vapour takes place, by the mixture of warm and moist air, ascending the western slopes from a low level, with the cold air of the higher regions.

Dr. M. Hamilton made some remarks on Mr. Hart's paper, with regard to the extraordinary frost of the past winter, contrasting the extreme depression of the temperature in the latter part of December with the prolonged frosts of 1812, 1813, and 1814, of which he gave some personal recollections, observing that the frost in these years never reached so low a point as during the last winter, although in 1813 it lasted for eleven weeks, and in the month of May, 1814, the banks of the river were covered with blocks of ice.

Mr. Downie and Mr. E. Hunt also took part in the conversation, the latter pointing out a curious correspondence between the weather in the two equinoctial weeks of last year, the first day of frost having occurred, as will be seen from Mr. Hart's paper, on the 10th of September.

The President exhibited a new rifle-bullet, invented by Mr. Kennedy of Kilmarnock.

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February 12, 1861.—PROFESSOR W. J. MACQUORN RANKINE, *the President, in the Chair.*

Mr. William Houston, Merchant, and Mr. Charles Penney, Jun. Chemist, were elected members of the Society.

On the Stalactitic Sulphate of Barytes found in Derbyshire. By WALTER CRUM, F.R.S.

DURING a visit to Buxton in September last, I observed in all the lapidaries' shops quantities of a particular form of sulphate of barytes, of which a specimen had been presented to me a number of years before. This mineral occurs in stems from an inch to two or three inches in diameter, the transverse section showing it to consist of concentric layers, somewhat resembling oak in colour and structure; hence the name "petrified oak," which it often receives in that district. It is also sometimes called "onyx stone." When free from earthy matter, it is hard and translucent, taking on a fine polish, and is much employed in thin transverse slices, along with other polished minerals, to produce the mosaic work so much used in Buxton and its neighbourhood, for ornamenting the slabs and other articles formed of the black marble which occurs near Bakewell. It does not seem possible to account for such a structure by any other than a stalactitic process of formation, and there are also larger masses of from one to two cwts., which are perhaps the corresponding stalagmites. In every case it breaks with a radiated fracture, and resembles Bolognian stone more than any other variety of heavy spar. The production of a stalactite supposes previous solution in water, and subsequent deposition on exposure to the atmosphere. But I am not aware of any substance having been observed by chemists which can act the part of such a solvent, more especially any substance which can have so acted in the situation where these minerals occur.

Unfortunately, too, this stalactite is not found in the situation in which it was formed, but lying loosely among the stony soil which, along with it, fills up the interstices of the vein. Mr. Thomas Bateman, a gentleman of extensive acquirements in natural science, who resides on his property of Youlgrave, near Bakewell, in the immediate neighbourhood of the locality of this mineral, was kind enough to give me the following information in reply to inquiries I made of him regarding the circumstances in which this mineral occurs:—

It is found on Middleton Moor, in a field on the Duke of Rutland's estate adjoining to Youlgrave, on the southern slope of a hill of no great

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height in itself, though forming part of an undulating district of considerable elevation, perhaps 1,200 feet. It is found in a vein averaging 2 feet 6 inches between the cheeks, running N.N.E. and S.S.W., in what is locally termed dunstone, a magnesian variety of the first bed of the mountain limestone of the Peak of Derbyshire (not to be confounded with true magnesian limestone).

It occurs in *detached masses* of varying size, loose in the mineral earth forming the vein, associated with lumps of white specular sulphate of barytes and limestone.

The quantity of the mineral is as great at ten fathoms deep as at the surface. The vein has not been worked deeper, nor has it ever been worked more than 15 or 20 yards from the spot where, according to Mr. Bateman, it was first discovered in 1832. I have observed, however, in Phillips's *Mineralogy*, published in 1823, that sulphate of barytes is said to occur in the stalactitic form in Derbyshire.

On mentioning this to Mr. Bateman, he answers me that he doubts very much if the same variety of the mineral is intended to be described by Phillips, for he never saw nor heard of a single specimen having been produced before the discovery in 1832, although familiar with the extensive collection of local minerals formed by the late White Watson, of Bakewell, which was the result of fifty years' application. Perhaps, he says, the circumstance of our having several varieties of sulphate of barytes, generally botryoidal, but occasionally smooth-faced, found adhering to the cheeks of the veins, may account for it; but none of them present either the dark colour or wood-like structure of the mineral in question. They are all locally termed "cawk," and are available for the purpose of grinding into paint.

There is no evidence of the continuance of the formation of this stalactite down to the present time. On the contrary, the masses occurring in a fractured state and loose in the vein, demonstrate the cessation of stalactitic action.

There is no stream of water nearer than three miles, and the situation is too elevated for any stream to have existed since the present conformation of the country.

Sulphate of barytes is very generally found in the Derbyshire mines in connection with lead; but Mr. Bateman has never seen the same form of barytes in any other place; and, so far as I know, it has never been described as having been found in any other part of the world.

I have searched in vain, in works on chemical geology, for any fact which could lead to an explanation of the manner in which this mineral has been formed. A stalactite of carbonate of barytes is conceivable, inasmuch as, like the corresponding calcareous salt, it dissolves, to some

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extent, in water containing free carbonic acid; and the observations of Bischof, of Haidinger, and of Blum, go to show the possibility of carbonate of barytes, in crystals or in fragments, being decomposed without disintegration, by long exposure to a solution of an alkaline or earthy sulphate. We have also the fact, observed by Dr. Withering, when he first discovered the carbonate of barytes at Anglesark, that it gradually degenerates into sulphate of barytes on approaching the surface. There is, however, no particular fact which can lead to the conclusion that any process of decomposition has been at work in the present instance. Gypsum is the only sulphate we can imagine to have acted the part in question, and, in that case, carbonate of lime could scarcely be absent. The merest trace, however, of calcareous matter is discoverable in it, and the specific gravity, 4·302, indicates the absence of any considerable admixture of a foreign earth.

On Street Railways. BY T. CURRIE GREGORY, Civil Engineer.

AFTER introducing the subject, Mr Gregory proceeded:—The Rails used are an improvement upon the latest form adopted in America. They are made of rolled iron, and are flat, with a ridge on the one side of about three-fourths of an inch elevation, with a slightly rounded crown of about one and a-half inch broad, vertical on the outside and worked off into a round and hollow in the inner side, leaving a lower flat surface of about four and a-half inches broad, upon which the wheels of ordinary vehicles can run.

Many different kinds of rails have been used in America; many of them with a groove for the flanged wheel to run in, but none, till lately, intended to accommodate also the general traffic. The groove is very objectionable, inasmuch as the wheels of carriages are apt to get into it, and, when this happens, they are turned out with difficulty, and are often seriously injured, if not wrenched off. The groove also is apt to get filled up with small stones and mud, and in the winter time with snow, which gets compressed, and these obstacles often cause the cars to run off the rails. No such contingency need be feared in the case of the rail laid in this country. The rails, laid to the same gauge as the steam railways, 4 ft. 8½ inches, are firmly bolted to longitudinal sleepers, which again are secured to cross beams. The whole is firmly bedded in gravel, and the paving between is neatly laid to suit the horses' feet, while the causeway on each side of the track is laid close up to and flush with the top of the ridge.

The improved Cars, constructed expressly for this system of railway, are formed with an oblong body, the whole of the upper part of the sides of which have a series of glazed sashes or windows, the lower

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portion of which can be opened by sliding the sashes upwards, and are fitted with framed venetian blinds, which, when not in use, slide into recesses below the window frames. Each end of the body of the carriage is provided with a sliding door, for admission into the interior of the vehicle from a platform, which is on a level with the floor of the car, and is reached by steps on the sides of the platforms, so that the vehicle can be entered from each side at both ends. The roof is extended over the platforms at each end, and is fitted with seats, which are gained from the platforms at the ends of the car. A bell is fitted to each end of the roof of the car, and warning can be given by any passenger by the pulling of a rope which extends along the length of the car. The body of the car is mounted upon two pairs of flanched wheels provided with suitable springs. The brakes are formed by a system of rods and levers, which can be worked from either or both platforms by the driver, conductor, or both, and are so arranged as to act on all the four wheels of the car at one time. The cars are intended to travel either end first, the horses being attached thereto in such a way that they can be immediately disconnected, with their harness, pole, and so forth, from either end, and re-attached at the other. The cars are most commodious, and, as run at Birkenhead, are seated for 24 inside and 24 outside. They are 7 feet high, and are so wide that, when the seats inside are occupied, there is room for two rows of persons to stand in the passage. In an emergency, 20 can find standing room. The cars can be made any size, and in New York some of them carry 100 persons.

Having thus generally described the roadway and the car, I shall proceed to notice the chief objections advanced against the adoption of the system.

I. It is objected that the railway will take up a portion of the streets.

It is not intended to appropriate any portion of the streets, and prohibit any other vehicles from running on the trackway of the railway cars. Leave is simply asked to lay rails, such as already described, either in a single or double track, according to the width of the streets, up the centre of the carriage-way generally, with the right of running omnibuses with flanched wheels thereon. These rails will not in any way interfere with the ordinary traffic, which can run upon, cross and recross them without difficulty. They have no groove to lock the wheels of waggons, and, instead of offering any obstacles, present great advantages, as is shown by the readiness with which drivers avail themselves ot the flat part of the rail to relieve their horses, and increase their speed.

II. It is objected that the streets of Glasgow are too narrow even for a single track.

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This is not the case; for any street of 25 feet width between the kerbstones, and upwards, is amply wide enough for a single track. The cars are 7 feet outside, and, if room be allowed on each side for lorries to stand at shop doors, nothing more is required. Take 7 from 25 and there remains 18, or 9 feet on each side clear while the car passes. The cars proceed singly, like any other omnibus, and occupy the ground only as they pass over it. The width of the route from the Cross to Whiteinch varies from 33 to 52 feet in width, and this is ample for a double track; nor are any of the thoroughfares, likely to be occupied, of a less width than 25 feet. Mr. M'Questin, the engineer of Montreal, in his report to the Corporation, states that in Boston,—

Boylston Street,	with one	track, is	24	feet between	the kerbs.
Cambridge Street,	... one	...	20	...	...
Tremont Street,	... two	...	33	...	...
Cornhill Street,	... one	...	23	...	...

And the widths of Walnut and Chestnut Streets, the principal thoroughfares of Philadelphia, a city of 600,000 inhabitants, are only 26 feet, and they have each a single track.

III. It is objected that, if only one line be laid, assuming that the cars cannot leave the track, there will be no provision for their passing one another.

At regular distances sidings can be laid, or, as is the custom in the American cities, single tracks can be laid down parallel streets, and the omnibuses going up one route can return by the other.

IV. It is objected that the flanched omnibuses cannot leave the track so as to pass any obstacle, either moving or stationary, and those who advance this objection contend that they should not have a preference of right of way.

The flanched omnibuses can leave the track to pass any obstacle, if necessary; but it is not desirable, nor is it intended that they should. The true principle of Street Railway government is that the cars keep in a direct line, and that the lighter vehicles move out of their way. The main object in laying rails with a ledge is to reduce the friction so much that cars of a much larger size than ordinary omnibuses may be run upon them at a great saving of horse flesh and of tear and wear, and providing superior accommodation for the public. Now, it is plain that if the cars are to be dragged by the same horse-power from one end of the route to the other, within a specified time, they must not leave the rails; for if they had to be turned off for every obstacle there would be no end to the interruption; and, besides, one pair of horses would be unequal to the effort of repeatedly pulling the cars, full of passengers, off and on to the line. In fact, the advantages of the

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system would be lost. Confusion would ensue; while one of the great aims of the system is to systematize the traffic. How could the enormous traffic on London Bridge pass it daily if the vehicles were not confined to the tramways! Much of the confusion that exists in the streets of London would be removed by a little organization, and this the existence of railways would materially promote; for, as is found in America, the ordinary vehicles would fall into the line for their own convenience, and all would move on together without mutual interference.

V. It is objected that the gradients of the streets of Glasgow will not suit.

It would be difficult to find streets more suited for Street Railways than those of this city. On the route from the Cross to Whiteinch there is not one gradient worth mentioning, and on that to the Crescents from Argyle Street, the only one of moment is West Nile Street, which is 1 in 26. Here, if necessary, an extra horse can be provided. It is upon the level that the railway car has the greatest advantage over the ordinary vehicle on the road, in the proportion of 8 to 1, and this advantage no doubt diminishes as the inclination of the road increases, owing to the less proportion which the friction bears to the gravity of the load on the rails; still, on a gradient of 1 in 25, the rail has an advantage over the road of $1\frac{3}{4}$ to 1. Thus it will be seen that even up West Nile Street the railway car, with its load of passengers, will be drawn more easily than the same load could be on the causeway. The advantage of a smooth track is practically demonstrated by the trams laid in Dundas Street, Stirling Road, and other inclines.

In the city of Philadelphia the Street Railway cars surmount in some cases gradients of 1 in 20, and in the outskirts there is one of 1 in 10: here additional horses are required. In descending gradients the brakes have a perfect command of the machine, independently of the backing power of the horses.

VI. It is objected that the Street Railway system will be fraught with danger.

The cars are provided with two powerful brakes, by which they can be brought to a stand in half their length, without the aid of the horses; while at present a laden omnibus cannot be brought to a dead stop, when going at full speed, under three times its length. There is also a bar in front of the wheels to remove any obstacles. Further, they move in a direct line, so foot passengers will know where to look for them; while at present they frequently cannot cross Argyle Street or Buchanan Street with safety, not only from the number of omni-

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buses and vehicles passing, but also from the devious course they often take. When Street Railways are introduced the number of vehicles will be reduced, and the omnibuses superseded. Experience, however, refutes this objection, for it is officially recorded that out of *Thirty-five Millions* of people, who travelled in 1859 on the Street Railways in New York and Brooklyn, only *twelve* were injured, and those from their own carelessness.

VII. It is objected that no other carriages will be permitted to use the rails.

The flat part of the rails will be open to any carriage that may choose to use it, free of toll.

VIII. It is objected that there will require to be stations, and it will not be always convenient to go to them.

Stations are quite unnecessary. Waiting-rooms may be provided at the termini, or at intervals, for the convenience of passengers; but the cars will stop at any spot, either to take up or let down passengers.

IX. It is objected that the Street Railways will interfere with the alterations of pipes and sewers.

As the rails are to be laid on longitudinal sleepers the roadway will be easily diverted.

X. It is objected that if Mr. Train or any company get a grant they will have a monopoly.

Mr. Train asks for no monopoly. He seeks leave to lay down two pairs of rails from the Cross to Whiteinch, and to run his passenger cars thereon. He is willing to submit to any reasonable restrictions that the Corporation and Trustees of the streets and roads may see fit to impose, and to enter into engagements, that the public convenience will be respected. He is so fully satisfied of the success that must attend the introduction of his system, that he is not at all particular as to the terms on which he may get the grant; and if the authorities would only see it their interest to enter into negotiations with him, they would soon find that he seeks no monopoly. He asks for no exclusiveness. Any vehicle may run in opposition to his cars, even upon the rails, provided that they be not an infringement of his patent. He depends for the public support upon the superior character of the accommodation he can supply. It will be with the public to say whether the system is to be extended, or whether the rails are to be torn up and the roadway restored to its former condition. That this will be done Mr. Train is willing to give a material guarantee. It is quite a mistake to suppose that the Corporation could, with any good result, lay down rails and take toll from any kind of vehicles with flanched

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wheels that choose to pass over them. A slow and a fast traffic cannot be worked at the same time, unless provision be made for the fast carriages passing the slow waggons by leaving the rails, and this, we have endeavoured to show, is inadmissible in the system of street railways.

XI. It is objected that the value of property will be reduced by the introduction of Street Railways.

Experience proves the opposite. It has been found in Philadelphia that since Street Railways have fairly got into operation, the value of property in the suburbs has increased from 30 to 50 per cent, while that in the business parts of the city has not decreased. In fact, the shopkeepers, who were at first the strongest opponents, are now the chief supporters and stockholders.

If rails, radiating from the centre of the city, were laid to Partick and to the different suburban villages, I do not venture too much, I think, when I say that ere long the ground along these routes would come into the market for feuing, and we should see mansions and villas, and rows of cottages for the working classes, springing up, again to be drawn within the limits of the city, in the course of years, by the unfailing law of progress. Already are our business men seeking for more commodious premises; and whole ranges of buildings, but very lately occupied by them as residences, are being converted into offices. Wearied with the city during the day, they seek relief by retiring to country villas for the night. In doing so they gain pure air; but their families lose many advantages; while both might be secured by a residence sufficiently removed from the city, and yet connected with it by a regular, safe, comfortable, and inexpensive communication.

XII. It is objected that Street Railways will not pay.

We have it from official records, that the New York City and Brooklyn Railways, from bribery and corruption, cost from £12,000 to £36,000 per mile, and still they divided from 5 to 12 per cent. in 1858. The road that cost £36,000 per mile, notwithstanding this enormous expense, divided 8 per cent.

In that year they carried 777,000 passengers per mile, while the Caledonian carries only about 16,000 per mile. They earned £7,600 per mile, while the Caledonian Railway earns not more than the half of this sum.

From these facts we infer—considering that Street Railways in this country need not cost anything like the sum mentioned—they will pay a handsome dividend; that the popularity of the system is clearly shown by the large number of persons who use them; that the street railway system has an immense superiority over the omnibus system,

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for on no route could our present vehicles pay a dividend with an outlay of £36,000 per mile; that the streets must be greatly relieved of foot passengers.

No supposed disparity between this country and America can vitiate these deductions to such an extent as to make them inapplicable to ourselves. There can be no doubt but that which has been found so convenient and profitable by our cousins over the water will be good for us too

XIII. It is objected that the Street Railways have been a failure in Birkenhead.

If this had been the case I presume that the Bonds which Mr. Train had lodged as a guarantee, that he would pull up the rails if they were found to be a nuisance, would have been forfeited. Instead of this the Birkenhead Commissioners have decided to extend the Street Railways already laid. It is a very easy matter to get up an agitation against even a good thing: there are many people influenced by narrow prejudices ready for this. Such was the spirit shown towards the system in America; but, as we have already mentioned, those who were the most determined opponents are now the chief supporters. One of the grounds of complaint, "that the facility given to the public by the Street Railway cars tends to induce parties to visit Liverpool in the way of marketing," is a strong argument in favour of their introduction into large cities. *Facility of travelling is what is wanted.*

I can speak from observation that, notwithstanding some mechanical defects from the hasty construction of the road, the opening of the Birkenhead Street Railway was a complete success, and such was the opinion of the public press, without, as far as I know, one dissentient. Since then the road has been much improved, and those who were loud in complaint are now satisfied, and say that if it had been laid as it is now they would not have grumbled. About 140,000 persons have travelled on the road since the opening; and considering that the line is short, and that it runs through a thinly populated part of the town, we consider this a most successful result, especially as all the winter months are included. As a single line has been found sufficient in most parts of Birkenhead for the traffic, the company have wisely decided to pull up a part of the double track, and to apply the material in laying an extension which has been called for. Where the traffic is not heavy a single track with sidings at intervals will suffice. In some cases this plan is being followed in London. There is a Street Railway car factory now established in Birkenhead, which has already orders for about 30 cars; and a resident coachbuilder, who built five for the local line, is at present building four for Mr. Train for export to Australia, per order from Government.

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So much for objections against the system. Let me now state as succinctly as possible some of the advantages that will ensue from its adoption, and I may state that I do so from personal knowledge, having had the opportunity of seeing Street Railways in operation during a residence of some years in North America. Of necessity some of these have been already shown in meeting the foregoing objections.

Space will be economized and time saved.—The commodiousness and elegance of the cars will induce many people to ride who would otherwise walk, and thus the streets will be relieved of pedestrians. The regularity of the transit and the lowness of the fare will rob the cabs of many a hire, and hence their number will rapidly reduce; and, from the systematic manner in which they can be worked, and the direct line they will take, much less room will be occupied by them than is at present by the omnibuses.

There will be no longer any necessity for one to wait in the rain for fifteen minutes for the next omnibus, after having had the mortification of seeing the one he expected to get pass him crammed full, and clustered on the outside by persons trying to get shelter from the projecting roof; for the cars will follow one another every five minutes at the busy hours of the day. Our lady friends may sigh for the day of Street Railways. There will be no packing in the seats in a close omnibus on a wet day, with a row of gentlemen standing between with dripping umbrellas. What an atmosphere! Need I enlarge? The ventilation will be complete, the passage twice the width of that in the present omnibuses, and the ingress and egress easy and comfortable at either end of the cars.

The noise in the streets will be lessened, and the mud and dust nuisance abated.—That such improvements will follow no one will doubt, and both will be welcomed by merchants and shopkeepers. The noise of passing vehicles in Argyle and Buchanan Streets is so great that, in the offices overlooking the streets, it is often very irksome to carry on a conversation, while the tremor of the building on its foundation frequently makes the hand pause before it completes a word.

Taxes will be reduced.—For the Railway Company will undertake to keep in repair eight feet of single way and sixteen feet of double way. Besides the omnibuses will be no longer running, and, from the convenience given to heavily loaded waggons on the flat part of the rails, the rest of the causeway will require less repair.

The transport of pig-iron to the Broomielaw will be facilitated as well as the moving of heavy castings and locomotives.—It would be a matter

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of no little importance to free the streets of the pig-iron traffic; for it is most destructive to the paving and annoying to the public. A special line might be laid for it, and the iron carried in waggons with flanched wheels capable of taking from 4 to 6 tons. Branch lines could be laid into foundries, and castings could be moved on low trucks fitted to the gauge, while locomotives and waggons could be run upon their own wheels, and delivered at the shipping place with a tithe of the power at present expended.

Communication might be also made with the railway stations, and goods (not express) might be taken from one to another by night, in the waggons, without break of bulk. In fact, we have little idea of the amount of capital that would be set free in Glasgow, and of the facilities that would be given by the introduction of Street Railways.

Glasgow has hitherto been in the van of improvement, why should she be behind now? Leave has been granted Mr. Train to lay rails in Birmingham, in Manchester, and in six different parts of London, including the route from the Bank up Moorgate Street, and he is meeting with success on all hands; and, now that the ground is fairly broken, I have no doubt but that the system will spread, and ere long we shall see Iron Rails laid down in the principal thoroughfares of every city in the empire.

Mr. Robson said the plan of Street Railways deserved to be supported. He had long been of that opinion, and had himself something to do with the introduction of the Street Railway at the general terminus connecting the Lanarkshire mineral lines with the Broomielaw. Along this railway 300,000 tons of coals are conveyed every year, without interrupting the street communication. He had no doubt that a Street Railway might be carried along the thoroughfares of the town without interrupting the passage. Still there were some points on which further experience was required before it could be clearly seen that the plan would prove unobjectionable in our crowded streets. Suppose, for instance, that a pig-iron cart were proceeding along the line at the rate of two miles an hour, and were followed by a passenger carriage going at the rate of six miles an hour, was the cart to get out of the way?

Mr. Gregory—Carts would come upon the tramway for their own convenience, and of course they would require to leave it on the approach of the passenger carriage.

Professor Rogers had witnessed the successful operation of Street Railways in the United States, where they had proved of great advantage, especially to his native city of Philadelphia. They had done all in

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that country which Mr. Gregory promised they would do in the streets here,—relieving the traffic on the streets, and not interfering to the extent which might be supposed with the ordinary conveyances. He mentioned that in Boston accidents sometimes arose from frost—a source of danger which would seldom exist to the same extent in this country; and recommended that care be taken that curves and heavy gradients should not exist together. Nothing could surpass the comfort with which the traveller goes along, sitting in one of these passenger cars, which proceeds at a speed of eight miles an hour, without a jar or irregular motion. He may read his newspaper or converse with his opposite neighbour, without disturbance, and arrive at the end of his journey refreshed, instead of being shaken and wearied as in an omnibus. The shopkeepers of Philadelphia were at first averse to the innovation, but now they are its greatest supporters.

Mr. Davidson said that in New York the system of Street Railways had been in operation for seventeen years, and he never heard of a single accident having occurred. He could testify to the comfort of travelling in these conveyances, as compared with driving in an omnibus. The rails had been laid down in streets in New York four or five times more crowded than any of the streets of Glasgow, and had occasioned no inconvenience.

The President remarked, that so far as his own observation of this system of railways extended, it confirmed the views of Mr. Gregory. He had occasion, at one period, to see a great deal of traffic in this way, in carriages which went one by one, stopping at various stations, and affording the utmost comfort and convenience to passengers. On the line to which he referred all sorts of strange machines were placed, till it was found necessary to obtain an act prohibiting such vehicles from coming upon the line. However, it appeared that in the present scheme, sufficient provision would be made for the regulation of the traffic. It was only reasonable that the heavy traffic on the streets should give way to the passenger carriages.

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February 27, 1861.—PROFESSOR W. J. MACQUORN RANKINE, *the President, in the Chair.*

Notes of a Journey across the Cordilleras of the Andes from the Coast of the Pacific Ocean to Chquisaca, via *Oruro, Potosi,* &c. By MATHIE HAMILTON, M.D., formerly Medical Officer to the London, Potosi, and Peruvian Mining Company, &c.

DR. HAMILTON was invited by Don Joaquin de Achavel, a native of Chquisaca, and a merchant of eminence, to accompany him to the interior of the continent, on a visit to various places in Bolivia; and being desirous to observe some of the phenomena presented in that extraordinary region, little known to Englishmen, he accepted the invitation. They started from Tacna on the 24th of August, 1827, accompanied by five servants, or guides, and 24 mules. The pass across the Cordilleras begins about six leagues from Tacna, and 2,000 feet above the level of the ocean. They began to climb the mountain on the second morning, and in the evening reached the crest of the Andes. It was by this pass that Generals Alvarez and Santa Cruz, with the patriotic army, 7,000 in number, invaded Bolivia in 1823.

"When on the crest of the Cordilleras, 15,000 feet above the ocean, a grand spectacle burst on us; for the snow-capped Tacora, whose summit is 19,000 feet above the sea, was now apparently within a few minutes' walk, though its base was more than a mile from us, so deceptive are snowy peaks to vision in those lofty regions, when the atmosphere is brilliantly clear, as it was this evening. We moved a little downward towards Tacora, and on the plateau on its southern front fixed our tent for that night.

"Tacora is an extinct or a dormant volcano, and is a truncated cone of large size. Though its crater has not been looked *into*, yet, judging from the circumference and form of the mountain, the crater seems to have been very great; many blocks of lava are strewn about the base of the mountain, and on the eastern limb there is an accumulation of sulphur, which, if in another locality, might be of use.

"Vegetation is dead here in August, but we obtained a few stunted shrubs from a rocky ravine, which afforded us a fire outside the tent, thus saving our charcoal. The night was calm, and the atmosphere so clear that the heavenly bodies shone beautifully, and appeared as if nearer the earth than when observed through the medium of air more dense and obscure; but the cold was terrible, so as to preclude stripping our clothes during sleep. The mules had not anything to eat, and

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were conducted a long way to drink; water being carried for our supper, which, on the journey, consisted of soup made of mutton, or flesh of llamas, and potatoes, with aji (spice of the coast); breakfast was of the same; but both night and morning we had tea first, it being taken while the cook was at work with the food, of which we partook twice only every twenty-four hours.

"We passed numerous small cones, consisting apparently of red porphyry; and, judging from their appearance, they are relics of volcanic action, which has been there exhibited to an extent unparalleled in modern times. The altitude of these little sugar-loaf-shaped hills is only from about 50 to 200 feet above the ridge along which we travelled to Colpa. It appears from the cuttings in the canal of Ochozuma, which is near Tacora, that the rocks in that region are mostly porphyry, granite, and gneiss; but red porphyry is most abundant. The volcano of Paucarani, on the ridge of the Cordilleras, is not far south from Colpa, and being higher than Tacora, it must be at least 20,000 feet above the ocean. At present it is the nearest to Arica of the volcanoes which are in active or visible operation. Paucarani throws out steam and sulphureous vapour, and masses of sulphur appear at its base."

On the 27th, the party, on leaving Colpa, resumed their journey, proceeding about due east among numerous small volcanic cones. "The route soon became tortuous and difficult, up and down precipitous rocks, which tested the muscular energies of both men and mules. In some places these animals displayed rare sagacity; for descents were not only very steep, but also zig-zag, and in going down such declivities, my mule, like the others, spread out its forefeet, and drawing together the hind legs, while it kept its tail in motion like a rudder, or as a rope-dancer does a balance-pole, it slid safely down with the rider over parts which, to a traveller uninitiated, might appear impracticable. In such cases the traveller should throw slack the reins, leaning back in the saddle, and hold firm with his knees, leaving the mule to manage itself; for if he attempts to control the animal it may lose its equilibrium, and both tumble to the bottom. In some parts of this day's journey the way was along paths on the sides of mountains cut horizontally, and so narrow as to be occasionally only about *twelve* inches wide, with a profound abyss on one hand and barriers of rocks on the other. Here I noticed that a mule with the usual cargo of two packages, which walked before mine, did not, while passing the narrowest and most critical points, avail itself of the centre or inner portion of the path for planting its feet, but cautiously moved along the outer margin. The creature seemed to know that had it not done

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so the package next the slope of the mountain above it must have been jolted against projecting rocks, causing a loss both of mule and cargo, an accident which has often occurred. Here an hour's work with a pickaxe, a few good marksmen, and plenty of ammunition, would make the position impregnable against any force."

Extensive deposits of salt were passed. "It was not dark-coloured, nor striated like the salt which is found lower down in exhaustless quantity on these Andes of the coast, which salt is cut out in solid blocks, and conveyed to Tacna, &c., for culinary purposes. The altitude of this salt pool or lake may be about 15,000 feet above the ocean. Fossil or rock-salt is found in enormous quantities along the Western Andes of Southern Peru, throughout many hundred miles from north to south, and at various elevations above the ocean, to more than 15,000 feet of altitude.

"This fossil salt is brought down by Indians to Tacna, and sold for culinary purposes. It is not white and pure like the chloride of sodium which is sold in England; but is of a dark colour, and often striated. The taste is intensely pungent. The quantity presented to observation on the Andes of South Peru is so enormous, that, in my opinion, it precludes the idea of its formation from any other source than that of volcanic or electrical action.

"It is not only the muriate of soda which is found in such immense quantity on these elevated regions, and many thousand feet lower down; between the Andes and the coast, at various elevations above the sea, and especially at the height of about 3,000 feet, various saline deposits are now known to exist.

"In the province of Tarapaca, which adjoins that of Tacna, there are vast deposits of saline substances, including sulphate of soda, or 'glauberite,' a salt of borax, and nitrate of soda, the latter in exhaustless quantity. It is a singular fact that the Spaniards were 300 years on this part of the Peruvian coast, and during that long period were ignorant of the existence of those saline deposits, which, since their discovery in 1826, have enriched many persons both there and in Europe, giving employment to thousands of men and mules, also millions of tons of shipping.

"In 1826 a French gentleman, M. Beck, discovered and wrought the nitrate of soda deposits on the pampa or plain of Tamarugal, in the province of Tarapaca. Messrs. Beck and Smith were the first shippers of nitrate from the hitherto little known port of Iquique, which is in latitude 20° 12′ S. The quantity of the nitrate is so enormous along the locality mentioned as to seem exhaustless, and the demand for it is constant both from Europe and the United States. It is found at

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places along the western margin of the pampa above named, in beds or layers from six to eight feet thick. Sulphate of soda is found more in the interior, and higher towards the base of the Andes. The nitrate is obtained at about thirty miles from the ocean, and the breadth of the plain of Tamarugal is about thirty miles more to the base of the Andes.

"At the elevation of about 15,000 feet we saw various troops of vicûnas and guanacas, who seemed to send towards us one of their number, as if to examine, and on his uttering the usual shrill cry or whistle, the others were seen scampering over the rocks.

"Rain never falls on the coast of the Pacific Ocean along many hundred miles, including the province of Tarapaca, which contains immense deposits of various saline substances, especially nitrate of soda. At Iquique, which is the port where the nitrate is shipped, not a drop of fresh water can be obtained from any natural source; for it must be brought from a great distance inland, or imported by sea, or made by distillation from sea-water, which latter method is now adopted at Iquique for the use of people there.

"It was not until after the discovery of the nitrate that distillation was put in operation; for, prior to that epoch, when I first resided at Arica, a boat was weekly sent from thence to Iquique, which is about 100 miles south from Arica. Said boat was loaded with water-grass and vegetables, &c., for persons at Iquique, who shipped silver obtained in the mines of Huantajaya, which, between 1726 and 1826, yielded silver to the value of £15,000,000 sterling, but now these mines, if not totally abandoned, give very little silver.

"With reference to the sterility of the Peruvian coast, it may be noted that the S.S.E. wind, which there prevails, being deprived of its moisture while passing the South American continent, reaches the regions of the Andes so free of humidity, that, blowing over the region on the west coast, it retains it a continuous desert."

On the 31st, the party began to descend the Cordilleras towards the great table-land or plain of Oruro. That day they passed a flock of llamas and alpacas, at least 10,000 in number. Vast numbers of these animals were also seen on the day following. The country about Oruro is sterile and bleak. The city, like Potosi, owed its existence to the silver mines, and, since these were relinquished, it has sunk from 80,000 to 4,000. The travellers spent several days in Oruro, whence they took their departure for Potosi, on the 16th of September. They arrived at Vilcopugio in five days, having seen on the way little else than rugged rocks, snow-covered peaks, and desolate hamlets. They crossed the mountain known as the Pass of the Condor under a snow-storm; and

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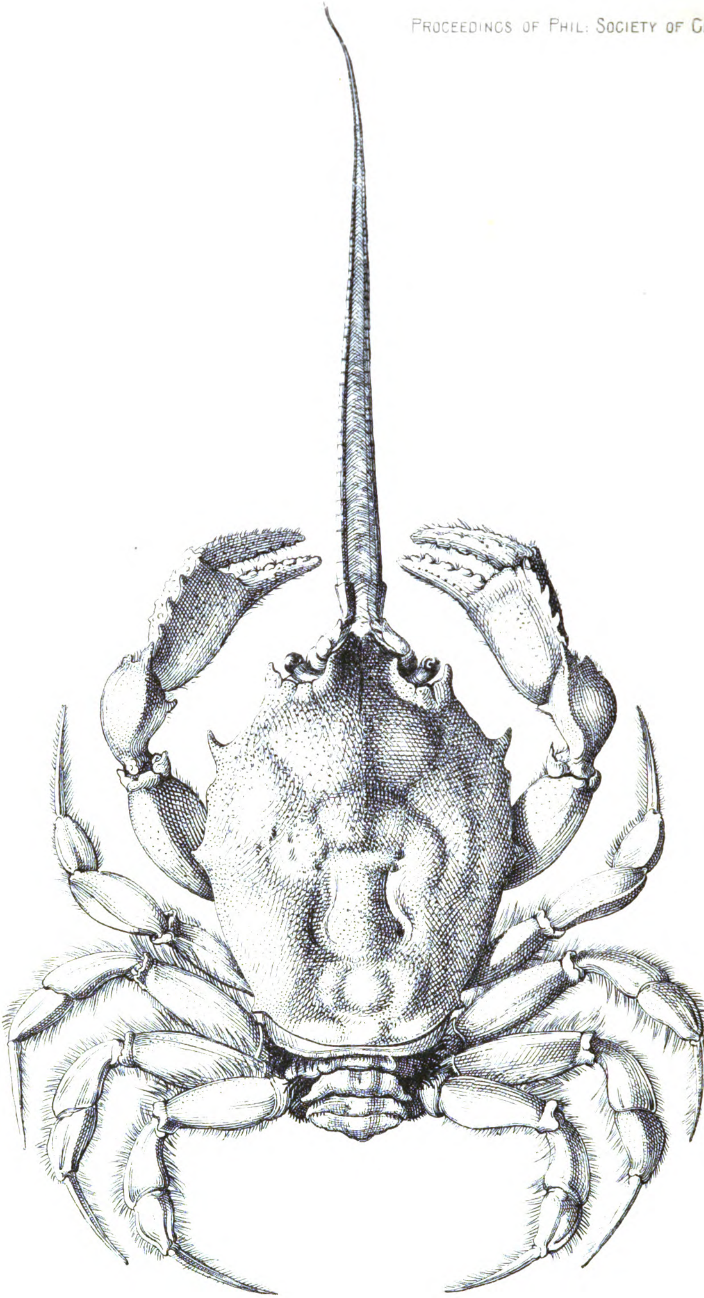

CORYSTES CASSIVELAUNUS.

Lith^d From Nature, by Maclure & Macdonald.

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at Vilcopugio visited the scene of the battle, in 1813, between the Peruvians and the Spaniards. (Dr. Hamilton's visit to Potosi is noticed in his paper on "Sensations experienced while Climbing the Andes," in *Proceedings*, vol. iv., p. 290.) From Potosi the travellers journeyed to Chquisaca. On the way they visited a family of Indians, and saw two females grinding maize in the open air; they were sitting face to face, with a stone between them, which was hollow, with another stone in it, which one of the women kept in motion while the other supplied the corn from her lap, thus illustrating, in that remote locality, the ancient oriental custom of "two women grinding at the mill." The paper concluded with a description of the city of Chquisaca, and its ecclesiastical and educational institutions.

March 13, 1861.—Robert Hart, Esq., *in the Chair.*

On the Uses of the Antennæ of Corystes Cassivelaunus, the Masked Crab. With an Illustration. By Mr. David Robertson.

The *Corystes Cassivelaunus* belongs to a genus of the brachyurous or short-tailed crustacea. It was first discovered and named by Pennant. It is a deep-sea species, and generally taken by the dredge, but is sometimes cast on shore during a gale. The exterior antennæ are longer than the body, and setaceous, with two rows of cilia. The eyes are borne upon large but short peduncles. The anterior limbs (chelæ) are twice as long as the body in the male, and about the length of the body in the female (represented in the figure). The specimen exhibited and figured was obtained at the island of Cumbrae. Mr. Couch describes the species as "scarcely common, which may be accounted for from its habit of burrowing in the sand, leaving its antennæ alone projecting above the surface;" adding that "these organs are of some use beyond their common office of feelers; perhaps, as in some other crustaceans, they assist in the process of excavation." Mr. Gosse describes the outer antennæ, when brought together, as "forming a tube." Each antenna is jointed externally, and hollow in its interior surface; the two edges are fringed with close-set hairs, the points of which are directed upwards, like the side-shoots of a quill-feather; and when the hollow surfaces of the antennæ are brought together, the cilia on their respective edges overlap each other, completing a prolonged tube. The use of this tube in the economy of

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the animal is not noticed in any description of the *Corystes*. Mr. Robertson placed a living specimen of the crab in a crystal jar, having a considerable depth of sand and sea-water, when immediately the animal burrowed down into the sand, abdomen foremost, by alternate jerkings of its sides, and without employing its antennæ in the operation. When it had descended to a sufficient depth to leave two-thirds of the antennæ uncovered, the exposed parts of the organs were slightly deflexed, in the manner in which they are usually delineated. But the true use of the organs became apparent when the animal went deeper into the sand, leaving only the tips of the antennæ at the surface. When it has adjusted itself in this position, in which it is its habit to continue, if not disturbed, the tube being formed by the approximation of the antennæ with their overlapping cilia, a free passage is preserved for the purpose of enabling the animal to carry on the process of its aqueous respiration. Particles of sand at first readily found their way into the tube, but they were observed to be presently thrown up in beautiful jets till the passage was cleared. When the shower of sand subsided, and the finer particles were projected beyond the opening of the tube, some of the coarser grains were retained over the extremities of the antennæ, so as to form a grating, serving at once to secure and obscure the orifice of the tube. It was expected that the return current would have been observed flowing out of the orifice, as in the siphonous mollusca; but this action was not perceived; and probably the absence of such motion is due to the ejected water being dissipated in its ascent through the interstices of the tube—an arrangement which may conduce still further to conceal the retreat of the animal. Mr. Robertson likewise observes, that the abdomen of the female is less developed than it is in the females of non-burrowing species, these latter being furnished with a large abdominal expansion, in order to protect the ova; whereas in the case of the *Corystes* such a provision is unnecessary, the safety of the ova being sufficiently secured by the animal's habit of concealing itself in the sand.

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On the Origin of Cyclones. By Professor H. D. Rogers.

Professor Rogers prefaced his explanation of the Origin of Cyclones, or Revolving Gales, by defining their nature and extent, and the tracts of the globe's surface to which they are chiefly restricted. He described them as portions of the atmosphere moving in an actively whirling or circular course, round a circumscribed still area or axis of comparatively calm air, each aerial particle following, below or near the surface, a spiral contracting orbit; but when near the vortex, pursuing an ascending helix until, at a variable height, the spiral path, more slowly rising, dilates with a continually and rapidly increasing circle of curvature, till it expires in some tangent line. Combined with this internal gyratory movement, the entire cyclone, viewed as a single form, itself moves in a very wide orbit through the atmosphere, floating obedient to the prevailing wind of the district.

The height, or depth rather, of the whole doubly conical vortex, is not invariably that of the entire atmosphere, but is in many instances, especially in the earlier stages of the cyclone's development and progress, limited to the lower stratum. This is evinced by our frequently observing that the upper air manifests, during the transit of the storm, a continued, gentle, independent movement, as if it were not at all involved in the shifting gale below. Indeed, the cyclones of the West Indies and the United States not unfrequently allow the beholder of the weather to gaze through the openings of the storm-rack, furiously driven and torn by the north-east gale of the first stages of the tempest, and to discern the fair weather cirrus floating serenely from the opposite quarter, the south-west, at a great altitude.

An essential phenomenon of all these revolving storms is the oppositeness of the direction of rotation of the air itself within the gale, from the direction of revolution of the whole cyclone in its geographical orbit. In the northern hemisphere the air embraced in the cyclone whirls from the east by the north to the west, or dextrorsally, while the cyclone itself swings through a wide path, with an opposite or sinistrorsal sweep, while a converse antagonism prevails in the southern hemisphere.

No explanation of the origin of the cyclones can be deemed satisfactory which does not recognize and fully account for these curious but fundamental diversities of rotatory and orbital motion. Indeed, it is with a view mainly to elucidate this part of their phenomena, that the author proposes the hypothesis he here proceeds to develop.

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It is material to any correct theory of the origin of these revolving gales, that it should be in accordance with the laws of their geographical distribution. It must be borne in mind that, with scarcely a known exception, these storms arise within the tropics; indeed, in almost every conspicuous instance, near the equatorial margins of the northern and southern zones of the trade-winds, or not far from the great central belt of Equatorial Calms. It is also worthy of remark, that they do not prevail with the same energy and frequency in all longitudes of the tropical zone, but are most abundant and violent in only two particular tracts of it. One of these is the wide, deep sinus of the Atlantic, embraced between North and South America; the other, the less completely land-enclosed tract of the Western Pacific, or that of the Polynesian and Chinese Seas. A third less extensive area, much visited by cyclones, is the Southern Indian Ocean, especially its central and western portions.

All these conditions,—direction of rotation, course of revolution, greater prevalence in certain regions, and origination only in the belts of the trade-winds adjoining the zone of equatorial calms,—are compatible, Professor Rogers thinks, with the following theoretical explanation of the mode of generation of the cyclones:—He supposes that the superior east-west velocity of the air within the trade-winds, compared with its sluggish progress on the borders of the zone of Equatorial Calms, engenders a rotation of the air in the mid-Atlantic and Western Pacific in these two belts, with a westward progression of the axis of gyration of each whirling body of atmosphere, precisely as a swiftly-flowing current of water invariably produces small whirlpools where it is in contact either with still water or with a current moving in the same direction, but at a slower speed. This tendency to gyration must necessarily be *dextrorsal* in the *Northern*, and *sinistrorsal* in the *Southern* hemisphere, inasmuch as the impeding equatorial calm belt is on opposite sides of the whirls in the two instances,—on the left side North of the Equator, and on the right side South of it.

No doubt a feeble tendency to a rotation of the same sort must arise from the agency assigned by Dr. Taylor as the competent cause of the whole phenomenon—a heating of the atmosphere over some insulated spot, and a consequent indraught of the air from all surrounding quarters, the south-flowing portions of which, by lagging to the westward of the focal point, and the north-flowing, by pressing forward to the eastward of it, engender a spiral or obliquely centripetal motion. But it is easy to see, from the following considerations, that this cannot be the primary or main source of the gyration

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The cyclones of the Atlantic appear to originate, not among its islands, but over the open sea, midway between Africa and South America, where it is singularly destitute of any specs of land.

Again, these rotating storms seem never to arise in the *extra-tropical latitudes*, where, for any given distance from a centre of indraught, the easting and westing of the air due to the earth's rotation should be comparatively great; but they are developed near the equator, where, from the near approximation to equality of the circles of latitude or rotation, the assumed agency must be at a minimum, though the other—the true condition—the difference in the velocity of the parallel belts of eastward moving wind—is there at a maximum.

Thirdly, it fails to account for the amazing duration and persistency of the cyclones, after they have left their places of origin far behind them; nor does it explain the unquestioned fact that, instead of immediately and progressively declining in energy of rotation, they even augment in violence in the early stages of their progress. Moreover, if due to a stationary cause, like the warming of the air over some island, why does not every sun-heated spot of land within the tropical seas give origin, at the hottest seasons, to a continued succession, a perennial crop of these tornadoes?

We are compelled, then, to regard the tangential action of the trade-winds at their equatorial borders on the comparative still air of the equatorial calm zone as the main exciting cause of the rotation, or, in other words, as the generating force creating the cyclonic whirl; but there is another very operative auxiliary influence which must tend to maintain, and even greatly to increase, any rotation so awakened. This is the effect of the oblique direction of the great coasts upon which the trade-winds impinge. In the instance of South America, it is obvious that the trend of its northern shore from E.S.E. to W.N.W. must, by checking the westward velocity of the northern trade-wind on its southern margin, exert a similar influence to that attributed to the equatorial zone of calms, namely, to engender or augment an already excited atmospheric gyration, and in the required dextrorsal direction. In like manner the corresponding trend of the land in the East Indies may be conceived to create a tendency to a dextrorsal rotation there. Looking to the opposite or N.N.E. and S.S.W. trend of the South Atlantic shore of South America, and the nearly coincident direction of the eastern coast of Africa, we can as easily discern how a sinistrorsal rotation, once awakened in the southern trade-wind, towards its northern margin, must be materially assisted in its velocity and deflected in its path by the

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retardation exerted by those lands on the north-western side of the revolving body of air.

Upon this view, that the obstructing action of the land on one side of a cyclone moving obliquely past it, or parallel with it, contributes to maintain or accelerate the gyration, it is easy to see how the hurricanes of the western side of the Atlantic, the typhoons of the China Sea, and the cyclones of the Indian Ocean, so far surpass in violence, duration, and range of orbit the revolving gales of all the other tropical regions.

A West Indian hurricane, in passing through the Carribean Sea, has its northern or north-eastern semicircle more acted on, all the while, than its south-western; and so, after curving northward, and finally, north-eastward, *the same side,* the right-hand half of the circle, is still the most strongly impelled; for this side is next the Gulf Stream, or in the more actively moving belt of the great south-west column of air which so habitually flows from the Gulf of Mexico towards the North Altantic.

A similar configuration of the land in the China Sea, or eastern part of the North Pacific, must exert a similar tendency to keep the typhoons of that region rotating long after they have extricated themselves from the north-east trade-wind, and become involved in the extra-tropical south-west or northern counter trade-wind.

The escape of the cyclones from the trade-wind belts, within which they all seem to originate, into the extra-tropical counter winds, or the south-west and north-west breezes of the temperate zones, Professor Rogers attributes to the preponderating influence of the upper, or return current, over the lower or trade-wind, whenever the cyclone is once deflected into the polar side of either trade belt.

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March 27, 1861.—Professor W. J. Macquorn Rankine, *the President, in the Chair.*

On Explosions of Firedamp in Coal-mines. By Mark Fryar, F.G.S.

The constituents of coal are, carbon, oxygen, hydrogen, nitrogen, sulphur, and ash. There is a considerable variety in coals, arising from the different proportions in which these substances are found combined. The constituents of wood are about 49 per cent. of carbon, 6·4 of hydrogen, and 44·6 of oxygen, nitrogen, and ash; and from these proportions in wood, down through all the varieties of coal, to the formation of true anthracites, which contain about 95 per cent. of carbon, there is a constantly varying relative amount of oxygen and hydrogen, and, consequently, of carbon. Carbon is the fixed constituent, and the gaseous and oily portions are the volatile constituents. Coal, as found in beds and veins in the carboniferous series of rocks, is constantly undergoing decomposition, by which carbonic acid gas (CO_2), light carburetted hydrogen (CH_2), free nitrogen? (N), and perhaps in some cases, heavy carburetted hydrogen gas (C_4H_4), are produced. These gases fill the pores, joints, and fissures of the coal, and cavities and crevices in or in the vicinity of the coal, which have been produced by faults and other disturbances; and when the coal bed is penetrated by passages, or the various drivages made in colliery workings, the gases are eliminated in quantities varying directly as the tension under which they have been pent up in the various spaces in or near the coal bed. After the coal has been excavated from the mine, and brought to the surface, this decomposition still continues, or it may be, that the gases filling the pores in an attenuated condition are now the principal source of firedamp. Certain it is, however, that carburetted hydrogen gas has been given off from coal placed in the holds of vessels, in such quantities that destructive explosions have been the consequence. Coal left standing for a long time underground in the shape of pillars, becomes materially lessened in value, from the process of decomposition, as well as from the crushing effect of the strata overlying it. The condition of coal in the shape of a pillar is different from that of the coal before the exploration of the bed—hence the difference in the effect of decomposition under the two respective circumstances; and the condition of coal in the shape of an underground pillar of support differs from that of coal in the hold of a vessel—hence the discharge of gas from an underground pillar may arise from decomposition, whilst the gas, from an explosion of which vessels have been blown up, may be simply what has been slowly exuding from the pores of the coal.

That some coal-mines are almost entirely free from explosive gas,

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whilst in others it is produced in large quantities, may be accounted for in the following manner:—*First*, We must admit that, in some cases, there are likely to exist in the strata covering the coal to the surface natural fissures or openings through which the carburetted hydrogen gases—because of their being of lower specific gravity than atmospheric air—drain off from the coal beds as rapidly as they are generated from the coal. *Secondly*, The difference in amount of pressure and temperature under which coal must necessarily exist, owing to its different depths from the surface, and the difference in the mechanical structure of the rocks in which it is imbedded, is sure to affect the rate of decomposition. *Thirdly*, The age of coals is undoubtedly related to the progress, and perhaps to the process, of the formation of gases. *Fourthly*, The difference in the relative quantities of carburetted hydrogen and carbonic acid gases, produced by the gradual and continued chemical changes through which the coal passes from lignites to anthracites, must affect the explosive property of carburetted hydrogen. There is this fact, however, which must ever be borne in mind by colliery managers—a fact which has been confirmed by experience—namely, that coal-mines which have been extensively worked for many years without producing any explosive gas may at any period become a dangerously "fiery" mine. This may arise from the working places of the mine having advanced into coal under different physical and mechanical conditions from those of the coal hitherto worked; or, the very circumstance of the extent of the workings may have facilitated the generation of gases in the coal.

"Firedamp" is not pure carburetted hydrogen gas, but a mixture of this with atmospheric air. Sir Humphrey Davy writes,—"I have analyzed several specimens of the 'firedamp' in the laboratory of the Royal Institution. The pure inflammable part was the same in all of them; but it was sometimes mixed with small quantities of atmospherical air, and in some instances with azote and carbonic acid." The same experimenter discovered that when firedamp was present in atmospheric air, in any quantity greater than one-fourth of the mixture, it simply lighted up on a lighted taper being introduced, without any explosion taking place; when the firedamp formed less than one-fourth part of the mixture, an explosion ensued, and this increased in violence until the firedamp was diminished to one-seventh or one-eighth of the mixture. The intensity of the explosion then diminished until the firedamp was reduced to one-fifteenth of the whole, and at this point the flame of the taper was simply elongated. "The effect of enlarging the flame, but in a gradually diminished ratio, was produced as far as thirty parts of air to one of gas."

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The atmosphere of coal-mines may be made explosive by this firedamp being given off from the coal in small quantities over a large area of coal exposed by the workings of the mine; and, at a given time, the ventilation of the colliery may be sufficiently vigorous to carry off the gas, and in such abundance as to maintain the proportion of firedamp below that at which its presence is indicated by the flame of the miner's lamp or candle; but the condition of the colliers who are working in such a mine with naked lights, or with insecure, misnamed safety-lamps, is very far from being one of safety. By a decrease in atmospheric pressure, against which the tensive force of the gas in the pores of the coal has hitherto been simply sufficient to admit of the escape of the gas in the ratio of its production from the coal, the firedamp may be suddenly and rapidly eliminated. Careful observation of a barometer, kept for this purpose at the bottom of a pit, is the best and surest safeguard against this source of danger. It is not, however, simply the amount of pressure indicated by the barometer which ought to be received as a precaution against the atmospheric condition of the mine, but the periods intervening between the alterations of pressure, or the rapidity of the oscillations of the barometer, should be carefully noticed, and the effect of this as regards the production of firedamp properly understood by the underground officers. After the barometer has been for several days indicating a given pressure, and then suddenly falls, there is reason to be on the alert for a large production of gas, even if after the fall there still be a high pressure indicated; and when the barometric oscillations are very frequent, no matter what or where in the scale of pressures the range of these changes may be, they should be acted upon as tokens of fearful danger.

There are, however, other causes to be dreaded for the production of explosive gases than variations in the weight of the atmosphere. We have already alluded to the filling up of cavities and fissures in or in the vicinity of the coal, by gases arising from the decomposition of the coal; and as the working parts of the mine advance, these are successively reached, and their contents are poured out in voluminous quantities into the ventilating currents of the mine. These large issues of gas, or "blowers," as they are called, are among the chief sources of firedamp in mines, and in some cases they continue for years: instances of long continuance are, doubtless, owing to a connection of fissures or crevices over a vast area of coal-bearing strata. Again, the immense depth of rock under which coal is excavated is constantly undergoing alterations in the amount of crushing force, by the gradual removal of coal from beneath, on account of which firedamp may be forced out

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into the passages of the mine, either from the coal itself, or from the bituminous shales and thin coal seams above, when falls of the roof take place, or from seats of gas from below, through the heaving up of the floor "creep," by pressure of the overlying rock on the coal pillars or on "pack walls." Indeed, as long as the coal continues to be extracted, the mechanical state of the rocks far above the coal seam, and to a considerable distance below, will be ceaselessly altering: the whole of the strata within the compass of the underground workings, and of a thickness extending from the surface to some depth below the coal, being worked, are thrown into a condition of disturbed and very irregular motion; and on this account the barometer is *not a sure indicator* of a discharge of gas into the passages of a coal-mine; as every accession to the crushing power of the superincumbent rock is likely to increase the make of firedamp.

Not one of the many analyses of explosive gases collected in British coal-mines has shown the presence of olefiant or heavy carburetted hydrogen gas; but, as far as I am aware, there is nothing to render the formation of this gas impossible, and, indeed, it is said to have been detected in the Gerhard and other mines near Sarrebruck, and in considerable quantities in a lignite mine in Schaumburgh, by Bischoff. Carbonic oxide, I believe, is not likely to be a product of the natural decomposition of coal, where there is no evidence in the coal itself of a temperature sufficiently high for the formation of this gas from carbonic acid; but carbonic oxide may be found in the vicinity of trap dykes, where the heat has been of sufficient intensity to char the coal for many yards into the coal seam. Sulphuretted hydrogen may possibly be produced in the working-places of coal-mines by the decomposition of iron pyrites (the sulphuret of iron) in the coal, and where the safety-lamp is hung very near to or against the coal, small jets of this gas may be sent out against it.

I am not aware of the existence of any substance, or combination of substances, associated with coal, or of any process of decomposition of any compound having hydrogen as a constituent, by which, according to the present known laws of chemistry, pure hydrogen may be given off from coal in its natural condition in the mine. It appears that "a temperature much below ignition" is sufficient to produce water by a combination of hydrogen and oxygen, so that if, by any chance, hydrogen should be a product of the changes which are taking place in coal beds, the probability is that it would meet with oxygen, and form moisture. Sir H. Davy discovered that heavy carburetted hydrogen gas, mixed with the same proportion of air as made firedamp explosive in the highest degree, was fired by both charcoal and iron heated to

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redness; carbonic oxide mixed with two parts of air was fired by the same degree of heat; but that hydrogen and sulphuretted hydrogen, mixed with three-sevenths of their respective volumes of air, both exploded at the lowest visible heat of iron and charcoal.

May not a local formation of sulphuretted hydrogen escaping from the coal against which a hot safety-lamp was hanging, have been the cause of lighting up the firedamp in some cases of explosion? Since there is a *possibility* of the formation of pure hydrogen and sulphuretted hydrogen in coal-mines, it would be well to recommend the adoption of wire gauze of a "much finer texture" than that of the ordinary Davy gauze in all firedamp mines.

The following table given in Mr. Henry Pepper's interesting *Play-book of Metals*, shows five analyses of firedamp from blowers,—three by Bischoff, showing olefiant gas as a constituent, and two by Professor Graham, in neither of which has the presence of this gas been detected:—

	Bischoff.			Graham.	
Carburetted Hydrogen Gas,	83·08	91·36	79·10	94·2	82·5
Olefiant Gas,	1·98	6·32	16·11	—	—
Oxygen Gas,	—	—	—	1·3	1·0
Nitrogen Gas,	14·94	2·32	4·79	4·5	16·5
	100·00	100·00	100·00	100·0	100·0

In Sir H. Davy's interesting *Researches on Flame*, he states that "the ratio of the combustibility of the different gaseous matters is to a certain extent as the masses of heated matter required to inflame them. Thus an iron wire $\frac{1}{40}$th of an inch, heated cherry red, will not inflame olefiant gas, but it will inflame hydrogen gas; and a wire of $\frac{1}{8}$th, heated to the same degree, will inflame olefiant gas; but a wire of $\frac{1}{500}$th must be heated to whiteness to inflame hydrogen, though at a low red heat it will inflame biphosphuretted gas; but a wire of $\frac{1}{400}$th, heated even to whiteness, will not inflame mixtures of firedamp." From this it is evident that a mesh of much finer wire is required in the gauze of a lamp where olefiant gas is met with, than that used in the lamp accounted safe in a mixture of firedamp in which no olefiant gas is present.

The dimensions of the cylindrical gauze, as recommended by Davy for the lamp to be used in ordinary firedamp, such for instance as that shown by Graham's analysis in the table first quoted, are 8 to 10 inches long, 2 to $2\frac{1}{2}$ inches in diameter, $\frac{1}{40}$th inch wire, and from 28 to 30 wires in the warp and woof. The gauze generally in use in the Davy lamp, and one which is considered safe in practice, is about 7

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inches long, 1½ inches diameter, $\frac{1}{40}$th inch wire, and 28 wires to the warp and woof. A larger gauze is dangerous on account of the force of the explosions which take place in the interior of the gauze, and of the greater body of flame of gas which the larger gauze admits of. Flame is more easily passed through the gauze when highly heated, and the greater the volume of flame, the greater its tendency to be blown through the meshes of the gauze by a current of air, or by moving the lamp rapidly through air which may be comparatively motionless.

Among a series of experiments made by Davy, he found that "iron wire gauze of $\frac{1}{40}$th of an inch, and 240 apertures in the square inch, was safe in explosive mixtures of coal gas, *till it became strongly red-hot at the top;* a quick lateral motion enabled a gauze of few apertures to communicate explosion; flame confined in a cylinder of *very fine* wire gauze did not explode a mixture of oxygen and hydrogen; a certain degree of mechanical force, which rapidly throws portions of cold explosive mixture upon flame prevents explosion at the point of contact; azote, when mixed in the proportion of one to six of an explosive mixture, containing twelve of air and one of firedamp, deprived it of its power of explosion; and one part of carbonic acid added to seven of explosive mixture had the same effect. The combustion of explosive mixtures within and not without the gauze cylinder of a lamp is explained by the fact, that a current is established from below upwards, and the hottest part of the cylinder is where the results of combustion, the water, carbonic acid, or azote, which are not inflammable, pass out. The gas which enters is not sufficiently heated on the outside of the wire to be exploded, and as the gases are nowhere confined, there can be no mechanical force pressing currents of flame towards the same point." Notwithstanding the latter part of this quotation from the papers of this eminent philosopher, every one who has seen the effect of an explosive atmosphere in a coal-mine upon a Davy lamp, must have observed the presence of a degree of force in the interior of the gauze, by an explosion of the firedamp entering through the apertures of the gauze. And as this force is in a certain ratio to the bulk of gas within the cylinder, the danger of explosion must be increased by using a Davy lamp-gauze of larger dimensions than those already named. I quite agree with the clause in the verdict on the recent terrible explosion in the Risca Coal-mine, Monmouthshire, which recommended the use of the "Stephenson lamp" in preference to the "Davy." The glass cylinder inside the gauze of the former, with its copper cap, is the only difference in the principle of construction of the two lamps; but this difference is a very

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important additional safety. The glass is a shield against currents to which the lamp may be exposed, and the danger arising from exposing an unprotected gauze to rapid currents of air or other gases was pointed out by Davy himself. Again, the confinement of the products of explosion of firedamp from contact with the flame of the lamp, is so effectual by the glass, that no sooner is a Stephenson lamp placed in an explosive mixture than these products, namely, carbonic acid, steam, and nitrogen, are thrown back upon the flame, and immediately extinguish it. We have seen how gases are produced in coal-mines, and that the principal inflammable part of the firedamp is one volume of carbon, chemically combined with two volumes of hydrogen (light carburetted hydrogen); also, that the most violent explosion takes place when the mixture consists of one part of this gas with seven or eight parts of atmospheric air. It is well known that flame is a chemical combination—an action or a process—"not a thing," and that this process is a rapid and successive alteration in the physical properties and mechanical conditions of the combining elements. When the elements are present in the exact proportion required by the laws of chemical affinity, it is then that the action or combination is most instantaneous; hence in the following table is shown the reason why one part of carburetted hydrogen to about eight parts of atmospheric air are the proportions producing the greatest intensity of explosion:—

BEFORE EXPLOSION.	ELEMENTS.			PRODUCTS OF EXPLOSION.
Weight.	Volumes.	Atoms.	Weight.	Weight.
8 Carburetted Hydrogen,	14·33	1 Carbon,......	6	22 Carbonic Acid.
		1 Hydrogen,....	1	9 Steam.
		1 Do.,	1	9 Do.
144 Atmospheric Air,	144	1 Oxygen,.....	8	
		1 Do.,	8	
		1 Do.,	8	
		1 Do.,	8	
		8 Nitrogen,	112	112 Nitrogen.
152			152	152

The relative volumes of firedamp and air shown by this table are about 1 of carburetted hydrogen to 10 of air; and it would therefore appear, that where experiment has shown 1 to 8 to produce the most violent explosion, some other inflammable gas than light carburetted hydrogen must have been present, or this may be owing to the mixture of the carburetted hydrogen with oxygen. If there should be a greater proportion of either air or firedamp present than is just required for these combustions, it is very evident that the excess of either substance would interfere with the rapid or instantaneous series of changes produced in them by an elevated temperature, equal in degree to that of white

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hot iron bar, or to flame, excepting where some gas more inflammable than ordinary firedamp is present. The explosion of firedamp is in the first place owing to the sudden expansion, resulting from a decomposition and subsequent combination of the gases. The amount of expansion is said, by a good authority, to most probably equal three times the original bulk of the gaseous mixture before explosion; and motion being given to the body of flaming gas by this force, in a direction offering the least resistance to the moving flame, a rapid and powerful rarefaction of the atmosphere of the mine is produced, and a blast, terrible in its results, thunders through the passages of the mine, committing dreadful havoc of life, and shattering to a thousand pieces whatever doors or brattices, coal-carriages, supporting timber, or unprotected stoppings, may happen to be in its course. But little chance of life is there left for the man who has been fortunate enough to escape the scorching of the flame, and find protection against "the horrible tempest," unless, by a good provision in the arrangement of the ventilation of the mine for the occurrence of such a calamity, he is enabled to arrive quickly at a channel through which a current of pure air is passing from one shaft to another. You will observe in the table illustrating the changes which gases undergo in burning or exploding, that the results of explosion are, carbonic acid gas, water, and free nitrogen. Now, carbonic acid is an active poison, and operates upon the animal system in a similar way to other poisons. It is a constituent in the surface atmosphere, but only in the proportion of 1 per 1000 parts. When it forms $\frac{1}{300}$ part of the atmosphere it is said to produce an injurious effect, and 4 or 5 per cent. in the air of a mine appears to be sufficient to cause suffocation. Sir H. Davy found that an animal lived, though with suffering, for a short time, in gas containing 100 parts of nitrogen, 14 parts of carbonic acid, and 7 parts of hydrogen. This carbonic acid is the gas produced by charcoal fires in closed apartments, the fatal effects of breathing which have too frequently exhibited themselves in the badly ventilated and over-crowded houses of the London poor, and elsewhere; and many will, doubtless, remember how, during the Crimean campaign, some officers met with their death from this poisonous gas issuing from charcoal fires in their tents, the truly admirable and noble Captain Hedley Vicars being one who was, with difficulty, recovered from the grasp of this foe, to fall more gloriously, and with the highest soldierly honours, before an enemy of widely different colours. Nitrogen, although negative in its properties, and therefore differing from carbonic acid gas in this respect, is utterly incapable of rendering the least support to animal existence; and the steam or vapour of water, as a product of explosion, is useless as a supporter of life. Where men are

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found alive in a coal-mine, after an explosion of firedamp has taken place, it must be owing to the explosive portion of the underground atmosphere forming but a small fraction of the atmosphere of the whole mine, so that after the explosion there may still remain a large quantity of oxygen. From what has been said, it will appear evident that there are several deadly agents, violently or stealthily generated by an explosion of gases in mines—namely the scorching or burning by the flaming gas, the terribly destructive force of the blast or hurricane, the suffocating effects of clouds of hot dust driven before the blast, and the action of the poisonous carbonic acid gas.

As the specific gravity of carbonic acid gas is 1·524, that of atmospheric air being 1, it will always be found to occupy the lowest position among the products of explosion; and on this account, doubtless, many become victims to its fatal power who might have otherwise escaped, as they are likely to be first stunned and thrown to the ground by the force of the explosion; whereas, had they kept on their feet, they might have met with a little friendly oxygen and revivifying currents of purer air.

Water absorbs equal volumes of carbonic acid gas; so that if the collier had presence of mind to place some cloth to his mouth, after an explosion, and keep moistening it with his bottle of water or tea, it would be the means of prolonging his life, and give him a better chance of escape. It is extremely difficult to recover a person who has inspired a quantity of this gas, more so than when a liquid or solid poison has been taken into the stomach; the reason, no doubt, being the instantaneous effect of the gas compared with that of a solid or liquid. I can speak from experience of its effects upon the system during the period of consciousness, as I once had a very narrow escape from its deadly influence. It steals upon the senses with a painless progress, producing a dreamy sensation, in which you are aware of your condition, but totally incapable of making the slightest effort for your own assistance. The sense of sound seems to take precedence of the sense of sight in yielding to the fatal spell of the powerful gas; and in a very few seconds from the first indications of dissolution of matter and life, your own conscious existence has passed away, and, doubtless, a few seconds more and the dissolution would be completed. The feeling during recovery is very different from the agreeable sensation attending the first inspirations of the gas. A faintness, with oppression in every part of the body, and a tendency to sickness, result in the entire prostration of all animal strength. In addition to this, there is a peculiar dimness of sight and dullness of hearing, and a most oppressive headache, which

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continues for several days. The headache is not an acute, stinging pain, but a weight of pain which one would imagine arose from a disturbance and heaviness of the brain.

The means recommended to be used in cases of danger from breathing in carbonic acid gas, are, bathing the person with effusions of cold water, particularly over the neck and head; the administering of a little cold water, slightly acidulated with vinegar, if the subject can be made to swallow; clysters of water and vinegar, followed by others of senna and epsom salts. Attempts should be made to irritate the nostril by a feather, and apply strong smelling salts; blowing into the lungs through a bellows, by placing the nozzle of the bellows into one of the nostrils, and compressing the other with the finger. Blood-letting from the jugular vein is said to produce the greatest effect; or, otherwise, blood may be drawn from the foot. Of course, in all such cases, professional assistance should be obtained as speedily as possible. In cases of burns, Mr. Greenwell says, "no time should be lost in sending for the surgeon. I have found that, in the meantime, an application to the burn, freely, of a compound made by shaking together equal parts of lime-water and sweet-oil, affords considerable relief to the sufferer; and where liabilities to such burns occur, some of the preparation should be always kept on hand." Poultices of oatmeal and water afford very speedy relief.

Coal mining will always be, comparatively speaking, a dangerous occupation, however educated and skilful the managers and other officers of collieries may become; and we must therefore admit, that according to the course of things, there will always be a certain rate of accidents fatal and otherwise. But as we have already observed, this rate is at the present day in Britain fearfully above what it may be reduced to, by more judicious management and by a higher degree of education among the workmen,—an education specially adapted to their requirements in the mine. It appears that there are at present from 1000 to 1200 lives annually sacrificed, and a writer in the *Edinburgh Review* some time ago computed the number of non-fatal accidents in the same period to be not less than 10,000. Since the recent Act of Parliament required that every serious accident in coal-mines be reported to the Government Inspectors of Mines, we shall have more reliable information respecting the number of non-fatal accidents; and I sincerely trust that they will be shown to be far below the number above quoted. The late Mr. Herbert Mackworth, who, with Mr. Dickinson, the Mines' Inspector for the Manchester District, was sent by the British government to inquire into and report upon the mor-

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tality among coal miners of the Continent of Europe, stated that the mortality from accidents was, in the coal-mines of

Prussia, ...	1·89	killed per 1000	per annum.
Belgium, ...	2·8	Do.	do.
England, ...	4·5	Do.	do.
Staffordshire, ...	7·3	Do.	do.

From this it appears that the number of fatal accidents in England at the time when this comparative investigation was made, was 138 per cent. in excess of those in Prussia, and 60 per cent. in excess of those in Belgium; and that the accidents in Staffordshire were 62 per cent. in excess of the average of the whole of England. The coal-mines of England are, generally speaking, more extensive, and much more liable to explosions of firedamp than those of Scotland; so that, happily for the latter country, the rate of mortality from fatal accidents among its colliers is considerably below that of the former. For 1859 I find that the rate of fatal accidents in England is about 12·7 per million tons of coal raised, while in Scotland it is only about 9·3. The fearfully disastrous explosions of firedamp which have occurred in various parts of England and Wales during the past four or five years, have had the effect of greatly exciting public sympathy, and of directing general attention to this class of fatal accidents; and I think every one practically acquainted with the subject must admit that they are of a preventible character. We can scarcely, however, hope for any material decrease in the number of mine explosions until there is some higher and safer guarantee given for the proper qualification of underground managers.

On the Whin Floats and Dykes of Ayrshire.* By MR. JOHN GOODALL.

THE whin dykes of Ayrshire are very peculiar in their nature, and are almost invariably of a light colour, owing, probably, to there being a large quantity of feldspar in their composition. This kind of whin does not seem to occur elsewhere in abundance. The dark whins also occur, but comparatively few dykes are composed of them. From this it would appear that the Ayrshire coal-field has been subjected to at least two distinct disrupting agencies, as it is very unlikely that two kinds of whin have been disrupted at one and the same time, and in the same field. It is needless for me here to describe the various dykes which occur, as, in general, they resemble those which are found elsewhere. I shall therefore take notice only of such as differ from the generality, and those which are associated with the floats.

* The term "float" is a local one: it has been adopted by the mining engineers of this district.

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Whin floats do not seem to be of frequent occurrence, as no mention is made of them in works on geology and mining. The Ayrshire coal-field, however, has many instances of them. They are invariably associated with the light-coloured whin dykes,* and are themselves composed of the same substance. They may be described as horizontal dykes, intercalated between other strata, and have had their origin from dykes. Perhaps the most interesting one occurs at No. 8 Pit, Lugar. This district is very much cut up by both light and dark-coloured whin dykes. The float in this pit is particularly interesting, not only on account of its peculiar structure, but of its chemical action on the iron-stone with which it is associated. The whin has escaped out of a large dyke, and has forced itself between the bands of ironstone, over a space of about fifty or sixty acres, and is so uniform in thickness that one is apt to mistake it for a regular stratum. It is of a light-brown colour, somewhat like sandstone, from its resemblance to which the miners call it *freestone*. The float is thickest near the dyke from which it has originated, and is there about two feet thick. From this it goes on gradually thinning, till it is reduced to about eight or nine inches, and within a few feet of its termination. It now declines more rapidly, and comes to an end at a sharp angle. Along its course it has not kept itself between the same beds all the way, but has varied its position between the bands of ironstones. The distinct parting between these bands has, doubtless, facilitated its progress very much. It has, however, by no means followed it throughout. When once clear of the confused mass of whin and detritus of the adjacent strata from which the float has emerged, it first takes its position above the blackband ironstone, and below the mid mussel band, then breaking through the mid and top mussel bands which lie above it, it places itself above them both, making a very good roof for mining purposes. It does not, however, long continue thus; for a short distance farther on it is seen either between the two mussel bands, in its first position above the black band, or below the whole of the ironstone bands. Thus is it ever changing its position between the beds; but nowhere is it seen to leave the ironstone altogether, and lie between the adjacent strata.

The body of this float is composed of compact whin of a fine grain, and of a light-brown colour. Midway through the bed run two lines of a still lighter colour, almost approaching white. These lines are about half-an-inch broad, and about three inches apart from each other. It looks as if it had been owing to an after injection. These lines do not occur where the whin is less than eighteen inches thick. About three or four inches from the top of the float, and as much from the

* These light-coloured whin dykes are sometimes called freestone dykes.

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bottom, the whin assumes a spheroidal form, the rounded masses varying from the size of a grain of sand to that of a large pea. These pellets are sometimes joined to each other, without, however, squeezing into each other, and thereby altering their rounded forms; but they blend into each other, forming one mass, so that no parting is visible between them. They also exist independently of each other in a soft matrix of the same colour as the whin. This matrix is easily decomposed by the atmosphere, and when it has been lying on the waste binns on the pit-head the softer parts have been decomposed and washed away by rains, leaving rounded pellets strewed about. This seems to correspond with the experiments made at Dudley on basalt, which, after being melted and cooled at a certain rapidity, assumed the spheroidal form. The whin of the float must have cooled more rapidly at its surfaces of contact: this accounts for the difference of structure between the inner and outer parts. This spheroidal form does not occur over the whole extent of the float; it is wanting altogether where the float is thin. These spheroidal masses are arranged in beautiful order—no mixture of small and large pellets—where large ones occur no small ones will be found, and *vice versa*. They at times very much resemble dolomite; the difference, however, is quite apparent; the pellets which compose dolomite are not so uniform in size, nor are they so rounded. There is about four or five per cent. of magnesia in this whin, but it is unlikely that its structure is any way dependent on that. In the whin occur many cavities of calc-spar, pyrites, and other minerals. These cavities are often filled with mineral bitumen, which gives the calc-spar a brownish tint. The calc-spar crystals are often spangled over with minute crystals of iron pyrites, presenting a most beautiful appearance. They are generally met with near the contact of the float with its parent dyke.

The blackband ironstone, when it lies immediately below the whin, undergoes a peculiar change; alternate layers of the stone, each about two inches thick, are converted into bright yellow pyrites, and the natural structure is altered from a horizontal to a vertical grain. The unaffected bands of ironstone contain a good deal of carbon or vegetable matter, which may have protected the iron from the influences of sulphur vapour. The mussel bands, which also have a good deal of vegetable matter in their composition, are almost totally unaffected. Here and there, however, the shells have been converted into pyrites. In some places the blackband is pitted all over with little balls of pyrites through its entire thickness. About five or six acres of ironstone has thus been made unavailable for the blast furnace. The miners technically call the faces containing the pyrites *brassy walls*. A

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question now arises: Whence came the sulphur which has changed the carbonate of iron (FeO, CO_2) into the bi-sulphide ($Fe S_2$)? Did it come up in the form of vapour at the ejection of the dyke? If so, it must have continued oozing up for a long period, to have affected the beds to the extent that they are.

At the Battic Pit, Hurlford, occurs a series of interesting dykes associated with a float lying above the major coal. These dykes are parallel to each other, and run almost east and west. The float is hemmed in on all sides by other dykes and slips, and covers an area of about one hundred acres. The major coal is naturally nine or ten feet thick, about four feet of which has been burned away, and of what is left, about nine inches on the top is unavailable for fuel, as it is too much burned. The whin of this float is much coarser in the grain than the one already described, and also of a much lighter colour. Nowhere through the whole course of it is there a trace of the spheroidal structure. It is from three to four feet thick, and emerges out of a dyke about fifteen feet broad. There are smaller dykes, however, which have helped in its formation. Often isolated masses of coal are imbedded in the float, and the whin as often threads its way into the bed of the coal, and there terminates in a thick mass. The float does not keep a uniform thickness; it is often less than three feet, and is sometimes more than four feet thick. The minerals which occur in it are chiefly calc-spar and pyrites, of which many beautiful specimens may easily be obtained, as in some places where the roof has given way, the coal being wrought out from below. Slabs of whin of two or three yards square may often be met with, covered all over with calc-spar, sometimes associated with cubical iron pyrites. The structure of the coal next the whin is greatly altered. It has lost its stratification, and assumes a semi-crystalline form, in rude vertical columns of half-an-inch in diameter, and has a faint resemblance to the general appearance of coke. This, however, is only the case with about three or four inches of the coal next the whin, although the heat has affected the coal much farther down, and deprived it of its lustrous appearance.

The dykes have many veins of fibrous limestone (satin spar) running longitudinally through them. These veins vary in thickness from a quarter of an inch, or less, to about two inches and a-half. A single dyke may have more than one of these veins. The larger ones are at times joined to each other by thread-like veins of the same substance. They in some places split up into many branches, crossing each other, and forming a kind of net-work. These veins have probably resulted from the dyke cooling and contracting, leaving fissures, which have in time been filled up by carbonate of lime being deposited from perco-

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lating water. These dykes do not alter the position of the beds materially: the smaller ones show a downthrow *visse* on both sides. When the dyke is four feet thick at the bottom of a mine four feet high, it is only about three feet and a-half thick at top,—contracting, therefore, about one in eight.

In the Overtown Colliery occur two dykes, between which is a float. The dykes and float are similar to those at Hurlford, and affect the Ell coal in a similar manner. They, however, contain new facts not observed before. One of the dykes has been first erupted; then the other, in forcing its way up, has carried before it a wedge-like mass, which, being jammed in, has stopped the progress of the dyke any farther in that direction. Then it has insinuated itself between the bed of coal and blaise, until checked by the first dyke. A distinct parting is seen between the float and dyke first erupted, which would not have been the case had they been contemporaneous. The adjacent beds have been somewhat displaced; this may not be owing to the dykes, but to slips which occur near them. There is only one other dyke I shall take notice of, and that occurs at No. 1 Pit, Common, in the Soft coal. The dyke is altogether about two feet six inches broad, of a uniform thickness all the way up. It is in three distinct portions: the centre part is about two inches thick, and is composed of burnt coal; on either side of it is a wall of light-coloured whin, which is much softer than the mid vein, and yields readily to the pick. The coal on either side of it is a little burnt; its position, however, is not altered.

At Dalry there are floats associated with two of the coals: they lie in the heart of the coal, damaging it very much. As I have not seen these floats, I am unable to give details.

April 10, 1861.—Professor W. J. Macquorn Rankine, *the President, in the Chair.*

On an Apparatus for constantly indicating the Proportion of Firedamp in the Atmosphere of Coal-mines, and also for giving Alarm when the Quantity approaches the Explosion-point. By John Taylor, M.D.

The author first explained the usual mode by which the specific gravity of a gaseous mixture can be got, by weighing a hermetically sealed vessel first in common air and then in the gaseous mixture, and afterwards introducing the apparent loss or gain of weight in grains into certain

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algebraical formulæ. Having thus got the specific gravity of the mixture, mere inspection of a table of the proportion of air and firedamp necessary to produce the given specific gravity, would at once give the relative quantities. Thus, by a delicately conducted experiment, the proportion of firedamp in the atmosphere of a mine, as is well known, can be found at any time; but hitherto, so far as the author is aware, no attempt has been made to construct an instrument which shall, by mere inspection, constantly indicate the state of the atmosphere. Careful consideration readily points out that the apparent loss or gain of weight by a vessel weighed or counterbalanced on a beam would be affected by the temperature, the pressure, and the composition of the atmosphere as to its constituent gases. The last, viz., the proportion of the constituent gases, is the subject of inquiry; but the other two causes of change, viz., temperature and atmospheric pressure, will produce continual changes on the indications of the instrument, and would, unless got rid of, effectually vitiate its results. Thus the common mode of weighing a vessel in air, then in a gaseous mixture, and thence deducing the specific gravity of the gas according to the method practised in hydrometry of liquids, though it has been proposed previously by Mr. Simpson and others, as applicable to the purpose of testing the state of the atmosphere of coal-mines, is incapable, without continual corrections, of giving results even approximately accurate.

The instrument exhibited to the Society consists of a hermetically sealed tinned-iron cylinder, of about 700 cubic inches in volume, suspended to the arm of a beam of about two feet in length, and counterbalanced by another cylinder of exactly the same weight and size, suspended at the opposite end of the beam; the difference in the case of the two cylinders being that the one is pervious in its walls to the external atmosphere. The beam rests, by a knife-edge passing through its centre, on steel or agate plates placed on a supporting pillar.

The compensation for changing temperature is effected by means of a rod, about one foot in length, one-sixteenth of an inch thick, and half an inch in breadth, composed of equal plates of zinc, brass, and iron, soldered with their flat sides together in the order mentioned, the brass being between the other two. This bar bends by changes of temperature, and when fixed by its middle in a vertical position across the beam, moves weights, which are fastened to it, farther from, or nearer to, the centre of motion of the beam, so as to keep the latter stationary, even though the support afforded to the tin cylinder may change through variations of density in the surrounding atmosphere, arising from changes of temperature. The proper amount of compensation is attained by changing the position of the weights. The compensation

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for varying atmospheric pressure is obtained by means of a semi-circular box, composed of two doubly curved plates of brass soldered together, so as to enclose between them an air-tight space. The air is withdrawn from this space, and a species of Bourdon's barometer is thus constructed, which has the property of varying its shape or degree of curvature by changing atmospheric pressure. This curved brass box is fastened to the beam of the instrument in such a manner that the movements of its free end may carry a weight nearer to, or further from, the axis of motion of the beam, according as the atmospheric pressure becomes greater or less than its mean. A weight sliding on a rod attached to the free end of this barometric tube allows a power of varying the amount of compensation till the proper degree is reached.

The end of the beam is so shaped that its arms are deflected from the horizontal position through an angle proportional to the loss or gain of support experienced by the hermetically sealed cylinder. A scale is fixed near the end of the beam, on which the proportion of gas necessary to cause the index fixed to the end of the beam to point to any division is indicated.

A box covers the instrument, so as to afford protection from dust &c. This box can, at pleasure, be rendered nearly air-tight, and filled with atmospheric air, carried down the pit to it in a bag, so as to afford the means of adjusting the scale, &c.; and also as a means of at any time testing the accuracy of the instrument.

It is proposed that two instruments should be placed near each other, so as mutually to afford means of comparison, and thus to be a check on accuracy.

An arrangement can also readily be made by which alarm would be given when the cylinder descends so low as to reach the point which indicates danger of explosion. This object is attained by attaching to the bottom of the cylinder a slender, bent wire, which makes an electric communication between two cups of mercury when the cylinder sinks so far as that the points of the wires reach the fluid metal. The cups form part of a voltaic circuit, with electro-magnet and bell, in the manner practised in electro-telegraphy. Any of the forms of constant battery now in common use would stand ready to give an alarm by ringing a bell, and would require only to be refreshed with liquid perhaps once in six months, or longer.

The annexed wood-cut exhibits, in outline, the instrument as just described. P is the pillar of support. B B is the beam resting by its knife-edge on agate plates at R. V is the hermetically sealed cylinder, and E is its exact counterpart, only left pervious to air. T is the compound metallic rod for temperature compensation—the weights,

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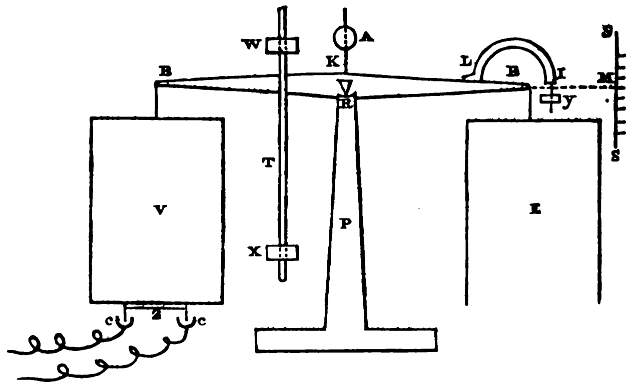
W X, are adjustable on T. A is a weight capable of sliding on the rod K, to give a means of adjusting the sensibility of the balance. L I is the



curved brass box for pressure compensation. Y is a weight which can be adjusted on the rod which is fixed to the movable end of L I, in such a position that accurate pressure compensation may be attained. M is the index or pointer, and S S the scale. It is easy, by proper adjustment of the weight A, to render evident the effect of $\frac{1}{500}$th or even $\frac{1}{1000}$th of firedamp in the atmosphere. C C are the cups of mercury, forming part of the electric circuit, which is completed when the wire Z reaches the surface of the mercury. A thin film of oil spread on the surface of the mercury serves to prevent the occurrence of a spark when the circuit is closed or opened.

If two similar instruments were placed side by side, the galvanic circuit might only be rendered complete after both had descended to the point indicating danger. As the cylinders would remain at their lowest point so long as the explosive quantity of firedamp remained in the mine, the circuit would remain complete, and would indicate the state of the atmosphere, to an inspector, at the mouth of the mine, if a properly arranged pair of insulated wires were carried up the shaft.

The author further observes that, so far as he is aware, no advantage has hitherto been taken of the modern electric mode of communication in the works of coal-mines; yet, in several respects, it seems probable that much use might be made of it. Deficient ventilation, resulting from the accidental opening of doors in the passages of mines, is a frequent cause of danger. An arrangement might at once be made by means of an insulated wire, which would show to the superintendent of the mine, for the time, whether all the doors were properly shut, as then only would the circuit be complete and capable of carrying a

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current. And this might be done without danger of a spark igniting the gaseous mixture, supposing it to be in a dangerous condition.

Another suggestion for the use of the electric wire may also be made, though perhaps it may be thought of a more questionable kind—viz., that it would be easy by means of a gutta percha covered pair of wires laid along the passages of the mine, and having, in properly chosen localities, a break in the wire, leaving a small interval between the ends, to send a spark from a Rhumkorff coil, so as at any time to enable the inspector to satisfy himself that the mine was not in an explosive state before the working miners entered it.

There is another suggestion or proposal which, though it is not immediately connected with the present subject, may yet be mentioned —viz., that the hermetically sealed vacuum tubes, which can now be so steadily illuminated by means of the induction current from the Rhumkorff coil, seem to offer a mode of lighting mines where there is danger of explosion, which would be preferable to the Davy lamp in these particulars, that the light is hermetically sealed up, and has no communication whatever with the atmosphere. These luminous tubes could be hung up in the centre of the room, and if accidentally broken by a splinter of coal, or otherwise, all that would happen would be merely the extinction of the light, as the brush which would result from the exposed end of the wire is incapable of igniting a gaseous mixture.

The battery would be kept in a distant part of the downcast passage, where no danger from explosion could occur, and all that would be necessary would be the occasional renewal of the exciting liquids. Of course, explosion from attempts to light tobacco-pipes at these electric flames, as in the case of the Davy lamps, would be entirely prevented.

If electricity could be made harmlessly to light up those abodes of almost boundless power and wealth, but, at the same time, of darkness and danger, the coal-mines of Britain, another item would be added to the list of benefactions which the progress of science has bestowed on mankind.

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April 24, 1861.—Professor W. J. Macquorn Rankine, *the President, in the Chair.*

A Method of Increasing the Efficiency of Water-tight Bulkheads in Iron Ships, and of rendering them available as a means of Preventing Destruction by Fire. By John Taylor, M.D.

Some years ago, when making experiments on the conducting powers of different materials for heat, with a view of discovering the best material for the construction of fire-proof safes, I found that the saw-dust and sand with which the intervals between the different shells of the safe are usually filled were little better, as insulators for heat, than the mere empty space containing nothing but air.

In addition to the sawdust and sand, Milner, the well-known patentee, uses various saline substances, containing much water in their composition, which becomes vaporized when heat is applied, and this tends to keep down the temperature. He also uses, it is said, water in glass tubes sealed up and placed among the other non-conducting materials.

It occurred to me that by filling the space altogether with water alone, first having protected the interior iron surfaces with pitch or other varnish, to prevent rusting, the elevation of temperature above the boiling point might be prevented, so long as any water remained, a length of time which might be indefinitely prolonged, by making the interval between the shells of the safe large enough, or by connecting the space with the water-pipes of the building, the constant ingress of water pressure being stopped by a plug of wax or other fusible material which would melt on the first application of heat, and afterwards allow of a continual drenching supply of water to the spaces between the shells. A safety valve would of course require to be applied for the escape of steam.

This mode of securing safety from fire has not yet been applied in practice on the large scale; yet I can see no reason why it might not be perfectly successful.

Shortly after this it occurred to me that the same mode might be adopted as a means of preventing the destruction of iron ships by fire. Iron ships are now generally built with bulkheads, or transverse partitions of iron plate. These bulkheads are intended to be water-tight, and thus to be preservatives from sinking, in case of accident to the exterior shell of the vessel. Unfortunately, as is well known, they are seldom in practice found to be water-tight when they are required; and indeed there is no readily applicable mode of practically ascertain-

ing whether they are so or not, till an accident occurs requiring their services. The leak is discovered when it is impossible to remedy it. Of course, being composed of iron, these bulkheads are excellent conductors of heat, and are of little service in preventing the spread of fire from one compartment of the vessel to another. If, however, they were made of thinner iron, and double instead of single—that is, of two walls, with an interval between, and the two walls properly stayed together—an opportunity would both be afforded of testing the tightness, by filling the space with water, and also of preventing the spread of fire from one compartment to another, by introducing water into the space, when there was reason to suspect fire in any part of the ship.

As to the proper size of interval to leave between the plates of the bulkhead, circumstances would indicate this. If it were desirable that a man or boy should be able to descend into the space for repair, in case of leakage, probably not less than fifteen inches would do.

This space might in each case be intersected by one or two vertical cross divisions, and might serve as tanks in which the ship's stores of water could be kept; or the space might be made three or four feet wide, and could be used as a small hold for portions of cargo—thus preventing all loss of carrying-room.

If, in addition to these transverse compartments divided into cells, a longitudinal division were also constructed, similarly divided, and binding the cross bulkheads together, great firmness would be added to the ship; and, if properly arranged, so large a water-tight space might easily be secured, independent of the external shell of the vessel, that, in the case of passenger ships especially, it would be quite possible to render a great ship as safe from sinking as a life-boat, without rendering it more inconvenient than an ordinary dwelling-house, which is not left as one great room, but, without inconvenience, is divided into many smaller apartments.

A ship would thus have an internal skeleton on which to depend for stiffness and buoyancy, altogether irrespective of its external shell.

Against these and other similar innovations in shipbuilding, of course there is the objection of the cost of construction; but in the present case it may be stated that the additional cost would not be so very great, as the plates of which the double bulkheads were made, might be much thinner than when one alone was used; and also that the workmanship would not be of an expensive kind, as the walls of such compartments, being flat, are put together with the simplest and easiest kind of riveting machinery.

But when we think of the dreadful calamity of fire at sea, or of a great passenger ship sinking by a simple but uncontrollable imperfection

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in its outer shell, it seems to me that a question of expense should not in such a case be even named, far less be an insurmountable obstacle.

Shipbuilding art will never be perfect till it is able to produce a vessel which cannot be sunk by any of the ordinary accidents to which such structures are liable, and by which at present they are so easily and so frequently destroyed. I have no hesitation in asserting that the adoption of the above specified method of construction would render this desirable object easily attainable.

Mr. Simons said there would be no practical difficulty in carrying out the improvement suggested by Dr. Taylor; but shipbuilders would expect to be paid for it, and the cost in a large vessel might not be less than £500. The thin materials, such as were proposed for the bulkheads, would not meet the requirements of the Board of Trade; although, if the improvement were properly explained to the Board, it was probable that their consent would be obtained to a modification of the existing requirements. He considered the proposed improvement to be one of great value and importance.

The President mentioned several examples of the success of bulkheads of the ordinary construction in preserving vessels from sinking. There could be no doubt as to the efficiency of the plan proposed by Dr. Taylor; but no shipbuilder could afford to make such experiments at his own risk. The first thing to be done, was to convince the public of the importance of such an improvement, and then shipowners and shipbuilders would be willing to take advantage of it.

Mr. Simons believed that ships could be so framed as to prove indestructible, if marine insurance were abolished; but no shipbuilder could afford to build such vessels at the present rate of remuneration.

Dr. Allen Thomson brought under the notice of the Society a series of osteological specimens, illustrating some of the more remarkable contrasts and deviations from the common type of the Mammalia; and deduced from these some observations on the relations subsisting between such extreme variations of form and structure in the mammiferous skeleton, and the purposes they appear to serve in the economy of the several animals in which they occur. The principal skeletons which served as the basis of the author's observations were those of the *Quadrumana, Cheiroptera, Feræ, Pachydermata, Solidungula, Cetacea, Edentata, Marsupiata,* and *Monotremata.*

The President announced that this meeting terminated the Session.

Errata.—In page 54, *for* "a flock of llamas and alpacas, at least 10,000 in number," *read* "flocks."

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PROCEEDINGS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW.

SIXTIETH SESSION.

Anderson's University Buildings, November 6, 1861.

The Sixtieth Session of the Philosophical Society was opened this evening,—Professor W. J. Macquorn Rankine, the President, in the chair.

The President delivered an opening address, of which the following is an abstract:—

1. He said he should abstain from the attempt to give a general view of the progress and state of physical science; because he considered it almost impossible for any one man to be sufficiently well versed in the details of all branches of physics to be able to do justice to all of them alike. He should confine his remarks to that branch of science with which he was most familiar, viz., Applied Mechanics; and his address might be viewed as a sequel to the report on the same subject which had been presented by Mr. J. R. Napier, Mr. W. M. Neilson, and himself, to the Society on the 7th of April, 1858.

2. He recapitulated the general view of the nature and objects of Applied Mechanics, which has already been given in that report (*Proceedings of the Phil. Soc. of Glasgow,* Vol. iv., p. 207), and which, therefore, needs not be repeated here.

Inorganic Materials.

3. *Natural Stone.*—Great difficulty still prevails in judging beforehand of the probable durability of natural stone, especially of the granular calcareous kinds, such as Oolite and Granular Magnesian Limestone. Even the durability of apparently similar stone in ancient buildings proves to be no certain test. For example, Westminster Palace is built of Magnesian Limestone, apparently similar to stone which has lasted for centuries in old buildings, yet it is well known that some

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parts of the palace are rapidly decaying. Some writers suggest that phenomena of this kind may be caused by the fact that in the old buildings comparatively small stones were used, which were selected from the soundest parts of the rock; whereas in buildings of the present day very large blocks are used, in which it is necessary to take the rock as it comes, durable and perishable together.

4. For the *Preservation of Stone* many processes are used, which consist in coating the surface, and filling the outer pores of the stone with some durable substance that excludes air and moisture. Mr. Kuhlmann uses a solution of soluble glass, being an alkaline silicate of potash, which gradually gives up its excess of alkali to the carbonic acid of the atmosphere, and becomes insoluble. Mr. Ransome, by a double decomposition, produces silicate of lime in the pores of the stone. Others use drying oils, mineral wax, or "*paraffine,*" and other substances. Time alone can show which process is the best.

5. *Calcareous Cements and Mortars—Concrete.*—The art has long been known of making artificial cement and hydraulic lime equal in every respect to the natural materials, if not superior. This we owe mainly to the chemical researches of Berthier, and the practical trials of Vicat, Pasley, and others. The use of *concrete*, of which hydraulic mortar forms so important a constituent, continues to extend; it has been employed in the foundations of works of the greatest magnitude and importance, such as the new Westminster Bridge and the new harbour works at Greenock; and the blocks of concrete used instead of large stones for the facing of breakwaters have lately, in some examples, been made of the great size of 27 cubic yards. The necessity, however, for a certain degree of caution in the use of concrete under great pressure is proved by a fact that has recently been brought to light, viz., that the hardening of hydraulic concrete is retarded by intense pressure. The reason of this is probably that the concrete expands in setting, as water and various other substances do in freezing; and the pressure, by resisting that expansion, opposes the setting.

6. *Asphaltic or Bituminous Cements,* though of organic origin, may be classed amongst inorganic materials, as not being actually organized. A most important use of *asphaltic concrete* (as a mixture of asphalt and broken stone may be called), to which it has of late been extensively applied, is that of building in sea-water, which is found slowly to dissolve earthy cements. Asphaltic concrete is too expensive a material to be used alone in making large masses of submarine masonry; but it is employed to form a coating, about three inches thick, to the enormous blocks of ordinary concrete that are used in building break-

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waters. A great want in the practical chemistry of the building arts is an artificial asphalt which shall be as good as the natural asphalt, maintaining, like it, a nearly uniform hardness and toughness at all seasons. Artificial asphalt is made and extensively used; and for such purposes as coating the arches of bridges, lining water-tanks, protecting masonry, and the like, it may be considered equal to natural asphalt, or nearly so; but for the purpose of road-making the natural asphalt has never yet been equalled. This subject is well worthy of the attention of practical chemists.

7. *Iron and Steel.*—The present time is marked by the great variety of new processes which have lately been introduced for making malleable iron, steely iron, and steel, and by the extraordinary strength of some of the materials produced by those processes, at a cost many times less than that of the old processes for making steel. We may now consider that materials of a tenacity ranging from about 70,000 to 140,000 lbs. on the square inch, and of any required degree of hardness from that of iron to that of steel, can be produced at a cost not greatly exceeding that of the higher qualities of malleable iron. For the most recent experimental illustrations of those facts, reference may be made to Mr. Fairbairn's experiments on the strength of Coleford gun-metal, Mr. W. H. Barlow's experiments on that of various kinds of homogeneous metal and puddled steel, and the voluminous and elaborate series of experiments conducted by Mr. Kirkaldy for Messrs. Robert Napier & Sons, and published in the *Proceedings* of the Institution of Engineers in Scotland, and in those of the Scottish Shipbuilders' Association. Those improvements in the manufacture of light and strong materials tend to facilitate very much the erection of great viaducts at a moderate cost, and to render structures possible which would have been impossible before. Amongst other experimental researches, there may be mentioned as worthy of special attention, those of Mr. Fairbairn on the great strength of iron rolled cold as compared with the same iron rolled hot, and on the effect of *often-repeated loads* on wrought iron girders. The result of the latter series of experiments is, that the "*factor of safety*" in iron structures, or the ratio in which the breaking load ought to be greater than the working load, is no longer a matter of guess, or of rule of thumb, but has been settled by precise experiment. Mr. Fairbairn has ascertained that an iron girder will bear the repeated application and removal of a load not exceeding about *one-third* of the instantaneous breaking load many hundreds of thousands of times without giving way; but if the load which is repeatedly applied materially exceeds one-third of the instantaneous breaking load, the beam always breaks in the end. Hence the factor of safety for a steady load is *three;*

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and according to a well-established principle, the factor of safety for a travelling or vibrating load should be double of that, or *six*.

8. *Various Metals and Alloys.*—Important researches have lately been made by Messrs. Calvert and Johnson on the composition, hardness, and other properties of various metallic alloys of great use in the arts, especially those of copper, tin, zinc, and lead. The general law appears to be, that the hardest alloy of a given pair of metals is their binary compound, atom to atom; the predominance of the atoms of either metal over those of the other diminishes the hardness. (*Manchester Transactions*, 1861.)

9. With respect to Organic Materials, there is at present little to add to what was stated in the Report already referred to. Reference may be made, however, to the use of a compound of coal-tar and quicklime for preserving timber, especially against white ants; and to the fact that, according to some of the best authorities, Indian rubber has been found to be superior to gutta percha as an insulating material for telegraph wires.

Construction.

10. *Theory of Resistance to Twisting.*—An important correction of the theory of the resistance of bars of other forms than cylindrical to twisting was made some years ago by M. de St. Venant, in the *Mémoires des Savans Etrangers*, vol. xiv., but has not hitherto received the attention that it deserves from scientific and practical men. The application of that correction reconciles the results of experiments formerly supposed to be conflicting. For example, according to the former theory, the modulus or co-efficient of the resistance of cast iron to wrenching was—

	Lbs. on the square inch.
As deduced from experiments on round bars, . .	28,000
As deduced from experiments on square bars, . .	32,000

but according to the improved theory, the results of experiments on square bars agree with those of experiments on round bars, both giving the same co-efficient, viz.—

28,000 lbs. on the square inch.

11. *Excavations.*—The most remarkable work of excavation now in progress is perhaps the tunnel through Mont Cenis, which is to be eight miles long. The blast-holes are made by a set of horizontal jumpers worked by machinery, which is driven by compressed air. If executed in the usual way, it would take about forty years to finish; but if it continues to go on at the present rate of progress, it may be finished in about ten years from the commencement.

12. *Foundations.*—Reference has already been made to the increasing

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use of concrete in foundations. The mode of constructing foundations in water and mud by means of vertical iron cylinders filled with compressed air during the sinking, and afterwards built up with concrete or masonry, is becoming almost universal. The use of Mr. Mitchell's screw piles, and Mr. Brunlees' disc piles, may be also referred to as means of making foundations for timber and iron structures with ease, and at small expense, in deep water and sandy or muddy bottoms. Diving apparatus, so important in building under water, has of late been much improved by Mr. Heinke and other inventors.

13. *Roads.*—When the true art of making broken stone roadways was introduced half-a-century ago by John Loudon M'Adam, the inventor recommended that each successive layer of road-metal should be reduced to a smooth and firm surface by the slow and gradual action of the ordinary traffic. There can be no doubt of the efficiency of this process as regards the consolidation of the roadway; but it involves great cost in the shape of horse-power and wear of carriages, besides subjecting the public to inconvenience and loss of time. Cast iron rollers have for a long time been employed to hasten the process, but they have not hitherto proved so efficient as the old plan. Better results, however, may be expected from rollers which have been lately introduced in France, of greatly increased weight, and driven by steam-power; one of these weighs ten tons.

14. *Tramways.*—The use of that sort of tramways called "street railways" was, in the course of the last session, fully explained by Mr. Thomas Currie Gregory, C.E., to whose paper reference is made for details respecting them.

15. *Railways.*—The most important question of the present day connected with the structure of railways is that of the best means of producing a smooth and firm, and yet not too rigid, permanent way. The fish-joint was a step towards its solution. Of late engineers have begun to recognize the advantage, in point of steadiness, of supporting the rail *by the shoulders* instead of *on the foot* (a system advocated thirty years ago by Mr. David Rankine). Mr. W. Bridges Adams has produced what is perhaps the best system of permanent way yet contrived, by bolting each rail between a pair of balks of timber, or of angle iron wings, which rest with a broad base on the ballast, support the rail continuously under its shoulders, hold it steady, and break joint with each other and with the rail. With a perfectly smooth track, the danger of very high speeds, about which much has lately been written, is entirely removed, and the expense, both for locomotive power and for maintenance of way, much diminished.

16. *Viaducts.*—There continues to be much discussion on the subject

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of the best mode of carrying lines of communication across wide and deep valleys. The characteristics of the principal forms of viaduct either used or proposed for that purpose have been stated in the Report of 1858, formerly referred to. Since that time the practicability of stiffening suspension bridges by suitable bracing has been tested experimentally in the case of the great Niagara Falls Bridge, which is safely traversed by railway trains at a limited speed, although the system of stiffening is far from perfect. Another opportunity of testing the practical success of the same principle, applied in a more complete and systematic way, will soon be afforded by a projected bridge over the Thames near Vauxhall, designed by Mr. P. W. Barlow.

Two important improvements have of late years been made in the art of constructing iron arches. One is that of building them of wrought iron plates and bars instead of cast iron ribs and panelling. A fine example of a bridge of that kind is that over the Theiss at Szegedin, designed by M. Cézanne. (See *Annales des Ponts et Chaussées*, 1859.) The other, which is due to M. Mantion, consists in the introduction of three *hinges* into an iron arch—two at each springing-joint and one at the crown. The effect of these is to do away entirely with the strains (sometimes very severe) which would otherwise arise from the action of heat and cold on the arch, and to reduce to the least possible amount the strains produced by an unequal distribution of the load on the bridge (as when one-half of an arch has a heavy train on it while the other half is unloaded).

17. *Shipbuilding.*—The scientific and practical advancement of shipbuilding has of late been much promoted by the establishment of societies for its cultivation. The transactions of those societies contain much information and discussion upon subjects of high interest, not only to naval architects and men of science, but to the public in general, such as the question of the best mode of rendering ships shot-proof. That question can be settled by experiment alone, and it is almost certain that there will soon be sufficient data for that purpose.

A new light has been thrown on the subject of the stability of ships by the curious investigations of Mr. Froude, who starts from the unquestionable principle that a body floating in a mass of moving fluid, and moving along with the fluid, is acted on by the same forces, and must move in nearly the same manner, with the portion of fluid which it displaces; so that, for example, if a ship be rolling about passively in the trough of the sea, a plumb-line in that ship will tend to hang perpendicular to the surface of the wave instead of vertical. The practical conclusions at which he arrives are of much importance, and are corroborated by experience.

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Recent experiments have tended to corroborate a view respecting the resistance of water to the motion of ships, to which a very brief allusion was made in the Report of 1858, viz., that when the ship is so formed as to divide the water smoothly, the only resistance that is practically important is that produced by friction—the friction being nearly the same as that of water flowing in iron pipes at high speeds. This con-conclusion may at first appear paradoxical; but it will seem much less so when it is explained that the proper method of computing the resistance comprehends not only the force with which the friction directly opposes the motion of the ship, but the resistance that is indirectly caused by friction, through the heaping up of the water higher at the bow than at the stern.

MACHINES.

18. *Steam Engines.*—Some experiments lately made with a steam-turbine of Mr. Gorman's (referred to in the Report of 1858) showed an efficiency about equal to that of an ordinary non-expansive high-pressure engine. An experiment of five hours' duration upon a marine engine with a cellular boiler, high-pressure, great expansion, and surface condensation, at which the President was lately present, gave a duty of 1,650,000 pounds, raised one foot by each pound of coal consumed. Recent experiments made in a ship of the United States navy have corroborated the principle which has for some time been generally admitted,—that it is essential to economy in the expansive working of steam that the steam should be prevented from condensing in the cylinder, and that such condensation, if it proceeds unchecked, neutralizes the saving that would otherwise be obtained by expansion.

19. *Railway Brakes* have been lately the subject of a series of experiments by Mr. Fairbairn, with most important practical results (as to which, see *Reports of the British Association*, 1859). These results show the advantage of continuous brakes, by which all the wheels of a train can be acted on at once.

INTERNATIONAL EXHIBITION.

20. The President concluded by congratulating the Society on the energetic manner in which the engineers and manufacturers of Glasgow had come forward to support the proposed International Exhibition of 1862. In the department of engineering and mechanical arts alone, the space applied for from Glasgow amounted to no less than 16,000 square feet; and he understood that in other departments it was equally extensive. These facts promised well for the success of the Exhibition, and for the manner in which Glasgow would there be represented.

The Society voted its cordial thanks to the President for his address.

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November 20, 1861.—Alexander Harvey, Esq., *Vice-President, in the Chair.*

The Society met this evening for the sixtieth annual election of its Office-bearers.

Before proceeding to the election, the Society, agreeably to its rules, received from the Treasurer, Mr. Cockey, the following Abstract of his Account for the Session 1860-61:—

Dr. 1860.—*Nov.* 1.						
To Cash in Union Bank,	£10	0	3			
Do. in hands of Treasurer,	3	16	6			
				£13	16	9
Annual Payments from Members,				321	16	0
Institution of Engineers, for Rent,				15	0	0
Union Bank for Interest,				3	4	3
				£353	17	0
Cr. 1861, *Oct.* 31.						
By New Books and Binding,				£66	14	4
Printing and Illustrating Transactions of the Society,				35	6	6
Printing Circulars, and Stationery,				14	4	0
Salaries,				116	17	7
Rent, Insurance, and Gas,				52	18	3
Repairs and Petty Charges,				7	7	6
Balance at the Bank,	£60	1	3			
Do. in Treasurer's hands,	0	7	7			
				60	8	10
				£353	17	0

The Society appointed the following gentlemen to be its Office-bearers for the year 1861-62:—

President.

Professor W. J. Macquorn Rankine, LL.D.

Vice-Presidents.

Professor Henry Darwin Rogers, LL.D.
Mr. Robert Hart.

Librarian.

James Bryce, LL.D.

Treasurer.

Mr. William Cockey.

Joint-Secretaries.

Mr. Alexander Hastie. | Mr. William Keddie.

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Council.

DR. FRANCIS H. THOMSON.	DR. ALLEN THOMSON.
MR. EDMUND HUNT.	MR. HUGH BARTHOLOMEW.
MR. JAMES R. NAPIER.	MR. GEORGE ANDERSON.
MR. RICHARD S. CUNLIFFE.	MR. WILLIAM EUING.
PROFESSOR GRANT.	MR. WALTER M. NEILSON.
MR. WILLIAM RAMSAY.	DR. THOMAS ANDERSON.

There were produced the plans of the alterations now being made in the buildings of Anderson's University, together with the plan of a proposed new hall for the better accommodation of the Philosophical Society.

The subject of the accommodation of the Society and its library was very fully considered, Dr. Bryce, Mr. Cockey, Professor Rogers, Mr. Walter M. Neilson, Mr. Walter Macfarlane, Mr. James Mackintosh, and others, taking part in the discussion. Mr. Neilson maintained that the greatest proportion of the members of the Society were in favour of removing the place of meeting to the west end of the city; and he gave notice of a motion for next meeting, that a committee be appointed to consider the propriety of looking out for better accommodation for the Society, in connection with other scientific Societies in the city.

December 4, 1861.—PROFESSOR W. J. MACQUORN RANKINE, *the President, in the Chair.*

Mr. Matthew A. Muir, 20 Park Terrace, was elected a member of the Society.

MR. WALTER M. NEILSON moved, "That a committee be appointed to take into consideration the propriety of looking out for better accommodation for the Society, in connection with other scientific Societies in the city."

The motion having been duly seconded, MR. CRUM described the nature of the improvements which the Directors of the Andersonian Institution were willing to make for the accommodation of the Society, either in the new building now in progress or in the hall presently occupied by the Society. Several members spoke in support of the motion, others in favour of remaining for some time longer in the present hall, on condition of the requisite improvements being effected for the accommodation of the meetings and the safety of the library. It

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was finally agreed unanimously that the motion do pass, with the addition, suggested by Mr. Crum, of the words "or otherwise;" and the following committee was accordingly appointed to "take into consideration the propriety of looking out for better accommodation for the Society, in connection with other scientific Societies in the city, or otherwise," viz., the President, Mr. Crum, Mr. James Young, Mr. Alexander Harvey, Dr. Bryce, Mr. Neilson, Convener; Mr. Keddie, Secretary.

Professor Henry D. Rogers communicated to the Society part of "An Inquiry into the Physical Causes and some of the Social Effects of the Abnormal Distribution of Temperature in North America." The Society voted thanks to Dr. Rogers for his discourse, and requested that it might be continued at a future meeting, to which he consented.

December 18, 1861.—Professor Rogers, *Vice-President, in the Chair.*

Mr. Andrew Watson, Etna Foundry, Lilybank Road; Mr. Andrew Coats, 2 La Belle Place; and Mr. Hugh Craufurd Smith, Southcroft, Shawfield, were elected members of the Society.

On Accidents by Fire from the prevailing use of Crinoline, and some Remarks on the Nature of certain Salts for rendering Light Fabrics less Inflammable. By Dr. Francis H. Thomson.

As year follows year and month succeeds its predecessor our best feelings and emotions are aroused and excited by the harrowing accounts that many of our best and fairest are being daily deprived of life by fire; for, indeed, accidents arising from this cause seldom or ever take place without a fatal ending, even where little or no apparent damage has resulted, the terror and excitement is so great that many have lost their lives from this cause alone. To expatiate on the innumerable cases which have frightened the world from its propriety would be beyond the limits of the few remarks I am about to make, although, for the sake of illustration, I may mention a few, and then proceed to describe the means which may be taken to alleviate this terrible evil, almost as bad as the "suttee" of India, where females, to the extent of 600 or 700, were wont to destroy themselves yearly.

The Registrar-General thus remarks in one of his reports:—"The fires of Smithfield and the suttee fires of India have been extinguished, but the fires on our own hearths destroy hundreds and deform thousands

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of English women and children annually. Assuredly some remedy may be found. Why are combustible dresses carelessly worn? Ninety-eight persons should not be burned to death in seven days."

Such deaths can scarcely be considered inevitable. The misery of these accidents, to which the young and gay are peculiarly liable, and from which there is no escape, is much increased, for surrounded as females are on all occasions of festive enjoyment by so many in the same position as themselves, bearing on their persons the elements of sudden and violent death, help of all kinds is utterly unavailable, and seldom, if ever, preserves life; a single spark from the fire, passing an unprotected jet of gas, is enough to set a whole ball-room in flames, as instanced by an event recorded so far back as the year 1800.

When Prince Schwartzenburg, the Austrian ambassador at Paris, was entertaining in his residence the first Emperor of France at a brilliant ball, a curtain caught fire, and in an instant the whole of the hangings and light decorations, such as garlands, and the walls themselves, which were partly built of wood, became one mass of flames, the dresses of the ladies began to blaze, and a general panic ensuing increased the danger and confusion. The Emperor's sister, Princess Pauline, and the Countess of Schwartzenburg lost their lives, the Emperor and Empress escaping with difficulty. Another instance lately occurred in Philadelphia, which must be fresh in the remembrance of all here, where fourteen ballet girls lost their lives from the dress of one having caught fire in passing a gas burner; the poor girl, as is usual, rushed about quite bewildered, and set fire to all with whom she came in contact.

Crinoline has much added to the danger by which females are surrounded, but so much has been written on this subject condemnatory of the practice that one can only enter a protest against its continuance. Since this article of dress was imported from France how many agonizing deaths have been chronicled, how many happy homes made desolate! The catalogue of deaths through this means would appal even the most hardened unbeliever. How many accidents of all kinds to children and others from the absurd entanglements which constantly arise in everyday life from the use and abuse of this unseemly appendage. In the history of theatrical accidents arising from the use of inflammable fabrics numerous cases could be quoted of a heartrending nature, one of which I give as an instance that even where no great actual damage took place death ensued. Madlle. Julié, a young *danseuse* well known on the Glasgow stage, some four or five years ago had her dress ignited in the Portsmouth theatre whilst performing, from contact with a gas jet; like the Miss Gales, she ran about much alarmed and excited, till one of the servants of the theatre seized and enveloped her in a

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large piece of canvas. She was very slightly burned, but the excitement and consequent reaction was so great upon a naturally nervous constitution that she sank and died on the third day. Miss Clara Webster, another dancer, also well known in Scotland, was so burnt at Drury Lane theatre, from her dress taking fire, that she also died. We might quote innumerable cases from this class, and it is surely the duty of all theatrical managers to insist not only on the use of fire-proof dresses, but that every care should be taken in covering exposed gas jets with wire gauze.

If we diverge from such public instances, and search into the annals of private life relative to accidents by burning, how many dear ties have been severed and valuable lives lost. I have here three extracted from one newspaper.

I might record the death of Mrs. Longfellow, yet fresh on our memories, but sufficient is before you to show that some legislative charge should be taken which would make it imperative on manufacturers of light fabrics to take every available and scientific means of palliating, if not curing, this state of matters.

I am quite aware of both the practical and chemical difficulties of any general or scientific application by which these views might be carried out, and by which the light fabrics now so much worn might be rendered non-inflammable, but much has been already done, and if my remarks only lead to increased general interest in this subject my object will be gained.

The Registrar-General of England thus observes in one of his reports, that of 8 deaths produced in London by burns in the week ending March 17, 4 were those of persons whose clothes had caught fire; 6 died from the same cause from March 17 to 24; from March 24 to 31, 4 persons are recorded to have died from the same cause; from April 7 to 14, 5 persons; from April 14 to 21, 6 persons; from April 28 to May 5, 5 persons; from May 5 to 12, 1 person; from May 21 to 28, 2 persons; from May 28 to June 4, 4 persons; from June 4 to 11, 2 persons—all in London. In the five years 1852 to 1856, 9,998 deaths were referred, in the civil registers of England and Wales, to burns. 2,181 are stated to have been caused by clothes taking fire. It must be borne in mind, however, that many deaths occur where the exact causes are not exactly stated: the above numbers are therefore below the amount. The *Lancet* quotes that in 1858 alone 3,125 arose from the same cause. Since then certainly matters have not been mended, for hardly a day passes that we do not read of accessions to these melancholy statistics.

Being anxious to lay before the Society a history of what has already been accomplished to render light dresses non-inflammable, and

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also elicit the practical difficulties which beset the manufacturer, and having ascertained that Messrs. Cochrane and Dewar, of Kirkton Bleachfield, near Glasgow, had been for some years taking a deep interest in this matter, and had practically carried out at their works the best processes yet ascertained as effective, I applied to them, and I have to acknowledge gratefully the extreme courtesy with which I was met.

Before exhibiting the various specimens, the result of their practical observations, and which so far exhibit a system of great simplicity, I shall, for the elucidation of the chemical portion of this subject, quote, with the approval of the Society, certain portions of a paper written by Messrs. Versman and Oppenheim, laid before the British Association in 1859, who are the patentees of the simplest process, and who, with much industry and skill, went through a course of experiments for the purpose of ascertaining the best and cheapest salts to be employed, and as they were much assisted in these investigations by Mr. Crum of Thornliebank we may therefore conclude that the different data are correct.

After giving the chemical reasons why one salt should be more efficient than another, and entering largely into all the phenomena elicited in a series of experiments carried over six months, and which were contained in an accompanying table, they conclude that only four appear to be applicable to light fabrics, namely:—

1. Phosphate of Ammonia.
2. Mixture of Phosphate of Ammonia and Chloride of Ammonia.
3. Sulphate of Ammonia.
4. Tungstate of Soda.

But after much practical experience in the works of Messrs. Cochrane & Dewar, Kirkton Field, they are led to conclude that of all the salts the Sulphate of Ammonia and the Tungstate of Soda are alone applicable.

Dr. Thomson here introduced three figures draped in muslin—one totally in unprepared, the next dressed in half-prepared muslin, and the third with muslin rendered non-inflammable by the Sulphate of Ammonia. The third did not burn at all, the second burnt but slowly, and the first was all consumed in three seconds: thus illustrating practically the terrible danger of the present mode of dress.

Amongst the many practical difficulties involved in this question is the fact, that a muslin dress, however well prepared by any fire-resisting process, will not guard against accidents, unless a definite and determined principle be carried out. If we take a piece of non-inflammable muslin or tarlatan, and place it over a petticoat which has not been so prepared, combustion will take place upon any accidental ignition. In the instance of ballet girls, it seems they wear at least seven or

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eight under-garments, all composed of light fabrics, and as it is a rule in all theatres that only the upper dress is supplied by the management, it becomes a serious question for the poor girls to procure a non-inflammable material suitable for the purpose; for the tarlatan costs 1½d. per yard extra when submitted to the non-inflammable process. As, however, these under-dresses are principally composed of muslin, which may readily be subjected to a starch charged with a non-inflammable salt, "Messrs. Versman and Oppenheim's Ladies' Life Preserver" seems so far to offer a solution of the difficulty; but, curious enough, even with the fear of death before them, these poor girls cannot be brought to see the necessity of securing safety for themselves; and even prepared starch, such as I have now the pleasure of exhibiting as the manufacture of Messrs. Wotherspoon of this city, although given gratuitously by the management, will in all probability be thrown aside if left in the hands of the parties themselves. And, indeed, the philanthropist, even when combining the best theoretical with the most practical, will find thrown in his path difficulties by those whom he most intends to benefit.

I have this day received, along with the specimens which are exhibited, the following letter from Mr. Cochrane, which contains so many valuable hints that, with the permission of the Society, I shall read it:—

"Kirkton Field, 18*th December*, 1861.

"F. H. Thomson, Esq., M.D.

"Dear Sir,—Herewith I send you some bits of printed muslins, also some very light spot Grenadine muslin; a portion of the Grenadine is unprepared, which you can exhibit in contrast with the prepared. All those are done with the "Sulphate of Ammonia," and you will observe that all the printed bits and one of the Grenadine bits are ironed. I did not try the exact heat of the iron by thermometer, but the simple test I gave you of water squirting off the iron is a very good test for practical purposes, to show that the iron is then too hot, so that we might say a little over 210° would be about the thing. I also send some of the liquid sulphate of ammonia and the hydrometer. I have made the liquid a little stronger, 2° over what I generally use, so that if in drying before the fire (as you propose) a little should be lost, you will still have a good result; a bit of the unprepared Grenadine cloth will serve to show this very well, being starched and all ready; 'cut a bit off, and dip it into the liquid, then dry, and you will have the desired result.'

"I wish to draw your attention to the piece of curtain particularly, as you will get a very peculiar result from it. It has been prepared so

that little or no starch is put into the *pattern*, the *plain* part only being starched. By this means the flowering absorbs more of the sulphate of ammonia, not having the coating of the starch; and what would otherwise have been the most inflammable portion is thus rendered most thoroughly non-inflammable, so much so, that in passing it over the taper you will find the muslin part getting all charred, while the pattern remains very perfect-looking. I have put in also a few bits of net, but, as it would require a stronger solution than I am making with, the prepared portion is not very perfect, although it shows a marked improvement on the portion not prepared, which I have put in. You can satisfy yourself, and judge if it would be judicious to exhibit. The contrast is considerable, but not perfect; of course a stronger solution is all that is required to make it right.

"If you pass a portion of the printed cloth over the taper, so as to burn it, you will find the threads retain a certain amount of strength, and they will act just as wire gauze in keeping down the flames of the taper—so much so, that a bit of unprepared muslin put on the top of it, and held over the flame, will not ignite; thus showing a preservative power against flame even when used as an external garment merely.

"I am sorry I have not been able to prepare for you a mixture of tungstate of soda; that would be very unworkable for your purpose with the means you will likely have at command, and rather than have an imperfect experiment, it would be better just to explain (as given by Versman) the mode of use.

"The mode of using the sulphate of ammonia is this,—We dissolve a considerable quantity at a time, and being impure, the liquid is very dark coloured—so much so as to spoil the colour of any goods; we allow this to strain for some hours, a very large precipitate takes place, with a lighter matter almost floating on the top of precipitate. This substance I have not yet examined. We then draw off the clear liquid, and dilute what portion we may require with pure water, using the hydrometer; and as mentioned to you, I find that 6° of density is a good working mixture for muslins, prints, &c., and if the muslin is highly starched, then a degree or two more.

"Having been very busy, I am sorry I have not been able to devote more time to get up things in a nicer shape for you.—I am, dear Sir, yours most truly,

"Alex. Cochrane."

Through the courtesy of Messrs. Versman & Oppenheim, I am enabled to exhibit to the Society specimens prepared by them, as also portions of the tarlatan procured for the use of the Glasgow Theatre,

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and which was rendered non-inflammable in Paris by the use of the sulphate of ammonia solution, a piece of the material having been analyzed by my friend, Professor Anderson.

The principal difficulty in the way of laundry-maids, from whom the greatest opposition arises, seems to consist in the peculiarity of ironing the prepared material; but a little experience, as explained by Mr. Cochrane, would soon overcome this; for if the iron be too hot, the salt will to a certain extent become fused, and the muslin will stick, so as to render it unfit for use, but by reducing it to the proper heat, this is overcome. Messrs. Cochrane and Dewar have prepared every kind of light fabric principally with the sulphate of ammonia, and in the specimens now exhibited you have ample proof of the practicability of so ordering our domestic arrangements that many of the lamentable accidents so often recorded may be avoided. Messrs. Versman and Oppenheim have likewise sent me specimens of the mixture patented and used by them, and the specimens of muslins accompanying packets have been prepared by this means.

The directions for using "The Ladies' Life Preserver" are as follows:—

"The contents of this packet to be put into one gallon of hot water. A sheet of linen should then be soaked in the solution and dried. The goods, after being well starched and rough-dried, are soaked in the solution until they are fully saturated; they must then be rolled in the piece of linen prepared as above-named, and ironed in the ordinary manner. Of all salts or preparations for the purpose hitherto proposed, this is the only one which does not interfere with the ironing. No other salt or preparation allows the iron to pass smoothly over the fabric without injury to its appearance or colour. Very little practice will enable any person to use this process, which will always prove successful if the salt is dissolved in the proper quantity of water. Too weak a solution does not perfectly protect the goods, and too strong a solution prevents the iron from passing. It is advisable to use a little more blue than usual. The solution does not become clear, but remains turbid, and must be well stirred before being used. It will remain good if kept to any reasonable length of time. One gallon of the solution will suffice for 10 to 20 dresses, or pairs of curtains, according to the material."

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Effects of the Frost of December, 1860, *on Vegetation in the Vale of Clyde.*

Mr. Keddie read the following statement, prepared from materials furnished to him by Mr. Clark, Curator of the Royal Botanic Garden.

The annual report of the Royal Botanic Institution of Glasgow, printed last week, embodies some brief notices of the effects of the severe frost of December, 1860, on vegetation in the Vale of Clyde, embracing the district from Corra Linn to the Isle of Bute. The information was furnished in a detailed form to Mr. Clark, the Curator, who has obligingly placed the communications he has received at the service of the Philosophical Society, with permission to make a more ample use of them than was practicable within the limits of a note to the Botanic Garden Report.

Before introducing the principal facts of the correspondence, it may be interesting to refer shortly to a report published in the *Transactions of the Botanical Society*, by Professor Balfour and Mr. M'Nab, on the effects of the frost on plants in the Botanic Garden of Edinburgh and other parts of the country not embraced in the communications now to be submitted to the Society.

The lowest temperature indicated in the Edinburgh Botanic Garden was on Monday, the 24th December, when the thermometer, as corrected to bring it to the Kew standard, stood at 6° below zero. The first plants on which the effects of the frost became visible were the common Laurustinus and *Aucuba japonica;* the next shrubs injured were the Bay or Cherry Laurel (*Prunus Laurocerasus*), the Portugal Laurel (*Prunus lusitanica*), and the Sweet-bay (*Laurus nobilis*). *Rhododendron ponticum* and hybrids from *R. campanulatum*, *Quercus Ilex* (the evergreen oak), *Q. Suber* (the cork oak), all suffered more or less severely. Among the Coniferæ, *Araucaria imbricata* showed symptoms of injury; a peculiarly fine tree, the largest in the garden, measuring 23½ feet high, with a stem 4 feet 3 inches round, the circumference of the branches being 54 feet, suffered more than any of the other larger specimens; in all low damp situations the Araucarias ultimately perished. Specimens of Arbutus, Aucuba, Sweet-bay, Laurustinus, Cherry Laurels, and most of the other plants named as being first affected, were at length found to have been fatally injured. Roses suffered severely, especially the climbing or wall roses. The misleto (*Viscum album*), growing on apple-stocks, was found to be very much injured, but it remained green and healthy when growing on oak

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and thorn. At the Botanic Garden, Cambridge, on the 25th December, the temperature was 5° below zero, and the species of plants injured or destroyed were the same as in Edinburgh. On the same day, at Glasnevin Botanic Garden, Dublin, the thermometer sank only to 24°, and the ground being covered with snow, the plants in a great measure escaped. In the north of Ireland the lowest temperature noted was 9° at Lurgan; at Belfast it was 11° on the 25th; the laurustinuses and roses were completely killed in the Botanic Garden at Belfast. Throughout an extensive district of Perthshire the temperature on the 24th was 2° below zero; on the 25th the mercury stood at zero, and on the 26th it sank to 3° below zero. At Taymouth, where the temperature of the loch is never under 43°, the vegetation escaped uninjured. At Forres, on the 24th, the thermometer ranged from a maximum of 27° to the minimum of 9°; and at Dalvey, where there is a valuable collection of plants, not only was vegetation generally uninjured, but the yellow jasmine and the primrose were in flower, and the *Cedrus Deodara* was putting forth fresh shoots. At Stornoway the gardener to Sir James Matheson reported that on the 1st of January, 1861, anemones were in flower; primroses on the 16th; snowdrops on the 20th; while the grass had never lost its green appearance, and daisies had continued to flower since November.

The temperature in the Botanic Garden of Glasgow on the 25th December, fell to 6° below zero; at Bothwell Castle garden, where accurate observations are made by Mr. Turnbull, the registering thermometer, in an open part of the grounds, on the 24th, fell to 11° below zero; on the 25th it stood at 3° below zero; and on the 26th it indicated 6° below zero, these being the lowest points reached during the winter, and they may be taken as representing the average temperature of the upper ward of Lanarkshire, including the neighbourhood of Glasgow. From a lengthened report submitted by Mr. Clark to the garden committee, it appears that the plants in the open ground suffered extensive injury. A storm commenced late on the evening of the 18th December, with a heavy shower of hail, mingled with flakes of snow; about midnight it calmed down, snow still falling. On the morning of the 19th the snow lay all over the ground about 9 inches deep, covering up many of the dwarf shrubs, and weighing down the branches of stronger and taller varieties, such as Irish yews and young pines. On the morning of the 23d, the thermometer indicated a sharp frost. The 24th, Sunday, was a clear and bracing day, succeeded at night by a keen frost. On Monday morning, the 25th, at 8 o'clock, the thermometer indicated 6° below zero, and remained below zero throughout the

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day. From the last-mentioned date, till about the 14th of January the frost continued intense. It fell with peculiar severity on the hybrid Rhododendrons, all of which, with one or two exceptions, were killed. The great majority of these were large and valuable shrubs, which had been transplanted from the old Botanic Garden in Sauchiehall Road. About 200 young Rhododendrons, of the more hardy varieties, brought from the Himalayan mountains by Dr. Joseph Hooker, were all more or less injured, involving a considerable pecuniary loss. Fifty-two large shrubs, consisting principally of the Cherry Laurel (*Prunus Laurocerasus*), the Portugal Laurel (*Prunus lusitanica*), the Sweet-bay (*Laurus nobilis*), and the Evergreen Oak (*Quercus Ilex*), were destroyed, although some of them which had been removed from the old garden had weathered the winters of more than a quarter of a century. The same fate was shared by *Aucuba japonica*, a valuable plant, which had attained a great size; *Araucaria imbricata*, and *Cedrus Deodara*. Plants of the common and Portugal Laurel were destroyed by hundreds. The loss would have been more extensive had not the ground been covered with snow. By means of the improved system of heating introduced into the hot-houses and conservatories, the valuable plants in these houses were preserved from injury.

Mr. James Napier, gardener, Corehouse, Falls of Clyde, mentions that hybrid and other Rhododendrons suffered severely, some of them, however, having partially recovered during summer. *Ceanothus azureus*, *Cydonia japonica*, *Ligustrum lucidum*, *Lonicera flexuosa*, *L. Douglasii*, and *L. Chapmanii*, on the wall, were killed. *Araucaria imbricata*, 14¼ feet high, and a doxen smaller specimens, were all destroyed. *Cedrus Deodara*, one plant 13 feet high, and two dozen of the same species, varying from 2 to 6 feet in height, are all dying off. *Cedrus Libani*, 13 feet high, *Cryptomeria japonica*, *Cupressus funebris*, and *C. torulosus*, are dead; also, *Pinus excelsa*, *Taxodium sempervirens*, and *Wellingtonia gigantea*, *Cotoneaster microphylla*, *C. rotundifolia*, and the common Holly, much injured, and many of them killed, some 20 feet high. *Peonia montana*, large plants, and *Paulonia imperialis*, both much injured. "We had several thousands of Portugal Laurels, many of them 20 feet wide and 18 feet high, but not one is left that has not been cut over. All the Bays, with the exception of the under branches of some of them, were killed to the ground. This is a black catalogue; but you may form some idea of the extent of our loss when it is added, that five men were employed for six weeks in cutting down the dead evergreens."

Mr. Andrew Turnbull, gardener, Bothwell Castle, whose statement

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of the temperature during the extreme severity of the frost has already been given, says that the effects of the frost were so disastrous that it would be much easier to mention the plants which did not suffer, than to enumerate those which were destroyed. The Arbor-vitæ common and Irish Yews, Tree Box, Juniper, and some of the hardier varieties of Rhododendrons and Kalmias, are the only evergreen shrubs which escaped uninjured. Of course the flower-buds of the Rhododendrons were almost all destroyed, and a large clump of the *R. ponticum* had to be cut to the ground. More than a thousand Portugal Laurels were destroyed, some from 12 to 24 feet in height, and from 8 to 26 feet in diameter. Most of them had been raised from seeds by Mr. Turnbull, and they were all trained to single stems. The common Laurel, though generally more easily injured by frost than the Portugal, suffered less on this occasion. Some of the Hollies were almost killed, while a few others sustained little injury. Some plants of the *Cedrus Deodara* were destroyed. On the flower-garden wall *Arbutus, Garrya elliptica, Laurustinus*, and all the China and other Roses were killed to the ground. Only one specimen of *Araucaria imbricata*, out of four, survives, much mutilated. Four plants of *Cedrus Deodara* have been killed. *Wellingtonia gigantea* is very little injured. *Taxodium sempervirens* and *Cryptomeria japonica* have both been killed.

Mr. Robert Ingram, gardener, Elderslie House, states that the thermometer reached its lowest point on Christmas day, being 8° below zero, while two other thermometers fell to 6° below zero. All the Portugal Laurels, without exception, were killed; some of the largest Hollies suffered the same fate. *Rhododendron ponticum* was a good deal injured, while the variety *Cataubiense* escaped. Common Jessamine, on the wall, killed; *Westeria sinensis* sustained little injury; Peach trees all but destroyed; *Araucaria imbricata*, 8 to 10 feet high, killed; also common Privet, *Aucuba japonica*, and Evergreen Oaks. *Mahonia* escaped without having a leaf injured. Hundreds of Portugal Laurels, from 20 to 30 years old, perished, and Hollies of the same age by the dozen. Standard Roses, with few exceptions, killed. Box (shrubs) were uninjured, although thoroughly exposed. Yews, Arbor-vitæ, and Junipers were scarcely affected. Pear trees suffered very much.

Mr. John Fleming, gardener, Bloomhill, Dumbartonshire, notes the indication of the thermometer on the 23d of December at 13° in the morning and 8° in the evening; on the 24th, at zero in the morning and 17° in the evening; on the 25th, at 10° in the morning and 7° in the evening; on the 26th, at 12° in the morning and 28° in the evening, these being the lowest points during the month. The following

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are amongst the plants which suffered from the frost of the 24th, viz.:—Sweet-bays, Laurustinus, *Pinus Webbiana*, top gone; *P. insignis*, nearly destroyed. *Cupressus torulosus*, dead. *Cephalotaxus Fortunsii*, an interesting tree lately introduced from the South of China, has suffered so much as to be all but dead. *Araucaria* was slightly affected, but has recovered. *Rhododendron Hendersonii*, here, and in this locality, dead. *Wellingtonia gigantea* stood untouched. Scarcely a budded Rose escaped. The Portugal Laurels were not touched. In this locality the winter frost has not so much effect on plants as the cold easterly winds of April and May.

Mr. Thomas Bird, gardener, Helenslee, Dumbarton, reports the destruction of Standard Roses, Sweet-bay, and Laurustinus.

Mr. Neil Leitch, gardener, Glenhuntly, Port-Glasgow, reports that the Laurustinus and the finer kinds of Roses were the principal sufferers, while Araucarias, Rhododendrons, Kalmias, and Arbutus escaped uninjured.

Mr. William Alexander, gardener, Helensburgh, states that Araucarias, Deodars, Laurustinus, Rhododendrons, and Laurels, although destitute of protection, weathered the frost uninjured. The *Wellingtonia gigantea* is quite hardy in this quarter.

Mr. William Dickson, Ferguslie House, Paisley, reports the lowest degree of the thermometer on the 24th, 25th, and 26th of December, when it stood respectively at 11°, 5°, and 7° below zero. *Araucaria imbricata, Cedrus Deodara, Cryptomeria Lobbii, Juniperus flagelliformis*, &c., killed. *Wellingtonia gigantea* suffered severely, some killed to the ground. *Aucuba japonica*, all the varieties of Arbutus, common and Portugal Laurels, Cotoneaster, *Thuja Smithiana, T. pyramidalis*, Sweet-bay, and various Rhododendrons, all cut to the ground. It is added that Ferguslie scarcely offers a criterion, in a general point of view, as the place is entirely unprotected, standing on the top of a hill, exposed on all sides except the east, where there is a partial protection. A storm of wind in the previous month of October had blackened all the exposed sides of the shrubs, leaving the evergreens in a more unprotected state.

Mr. William Sharpe, gardener, Eglinton Castle, states that on the 24th of December the thermometer fell to $6\frac{1}{2}$° below zero. All the Araucarias, from 2 to 20 feet high, were entirely killed. The Portugal Laurels and common Bay, some of them 30 feet high; Evergreen Oaks, some 30 feet high; Aucuba, Laurustinus, many varieties of Heath, and all the Standard Roses, were destroyed. Rhododendrons had their flowers blighted. *Wellingtonia gigantea* was much injured.

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Mr. Robert M'Lellan, gardener, Kelly House, reports an almost complete exemption from the destructive effects of the frost, so far as the Laurels, Rhododendrons, and Araucarias were concerned. On the 23d of December the thermometer ranged from 15° to 28°; on the 24th, from 11° to 19°; on the 25th, from 21° to 25°; and on the 26th, from 19° to 29°; the wind high, and from the east, and the most trying day of the last week of the year to plants and animals. The *Cedrus Deodara* was unscathed; one or two plants of the common Arbutus were killed, although others beside them remained uninjured; most of the China Roses, however, were cut to the ground. *Escalonia macrantha* stood out in the open clump at Kelly House with only partial damage.

Mr. Robert Ramsay, gardener, Mount Stuart, Bute, reports that the frost of last winter left the plants uninjured, specifying particularly the Camellia, Hydrangea, and Fuchsia, all growing in the open air.

January 15, 1862.—*The* President *in the Chair.*

Mr. Alexander Kinninmont, Druggist, was elected a member of the Society.

On the Geological Structure of the Ben Nevis Group of Mountains. By Dr. Bryce.

In this paper the author gave an account of the general structure of the Ben Nevis group, comprehending under that term the mountains as far as Roy Bridge. In regard to Ben Nevis itself, the paper was supplementary to one read to the Society last year. The observations therein recorded regarding Ben Nevis were confirmed, except in one particular, namely, that the greenstones and basalts which form the entire upper portion of the mountain from 1,600 or 1,800 feet upwards are confined to Ben Nevis itself, and do not pass across the north glen into the next mountain, which consists to its top of granite alone. A closer examination of the south-east side of Ben Nevis had shewn him that on that side the granite rises to nearly 3,000 ft., being much higher than on the north-west and north; while on the north front, in the bottom of the glen, its level sinks to little more than 1,000 ft., the line of junction with the greenstone plunging rapidly down from the edge of the cliffs, which bound the mountain on the north-west, into the depths

of the north glen, whence the line rises again towards the col at the head of the glen, which joins Ben Nevis to the next mountain north of it. Along this line of junction the author had, on his late visit, noticed in places portions of silicious slate, sometimes of conglomerate structure, entangled in the greenstone, or dividing it from the granite.

In regard to the mountains eastwards towards Roy Bridge, the author showed that they consisted generally of slate, of the silicious and micacious types, intermingled or alternating, and intersected by immense veins of quartz rock, which rise into the highest crests of some of the mountains. Two mountains only north-east of Ben Nevis and half of a third consist of granite,—all the rest to Roy Bridge and Loch Treig consist of slates or quartz rock. The strike and dip of these slates were adverted to as indicating that they had no relation to the granitic masses adjoining, their present position being referrible to other causes than the elevation of these granites. They seemed rather to be portions of immense folds of slate occupying the wild country to the north-west, and ranging through Scotland north-east and south-west, independently of the granitic outbursts occurring here and there among the Grampians. These mountains, the author considers, have no title to the dignity of a chain; they are certainly not a geological axis, and as little are they a geographical one, there being no line of persistent heights constituting a watershed.

The author, in conclusion, adverted to the non-existence of any other indications of glacial action than those referred to in his former paper, and to the singular paucity of transported granite blocks. They are more numerous about Glasgow than in the north-western valleys of the Ben Nevis group. The granitic mountains do not seem to have been a centre of dispersion, and to the north-west there does not exist any great body of granite.

On the Flora of the Island of Cumbrae. With Notes on the Climate.

By Mr. William Keddie.

The Island of Cumbrae presents many advantages for the study of marine zoology and botany. Its sheltered shores are peculiarly favourable for dredging; and no part of the west coast has been explored with greater zeal and success, or has afforded more extensive and valuable contributions to the zoology of the Frith of Clyde. The same shores yield to the marine botanist species of nearly all the algæ found in the

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Clyde estuary, and constituting little short of two-thirds of all the species recorded on the shores of the British islands. Considering the limited extent of the two islands, the land plants are not less remarkable for their variety. The catalogue now submitted to the Society of the flowering plants and ferns of the larger Cumbrae, and in part also of the lesser island, is the result of an examination conducted during the leisure of a residence at Millport during the last two summers, and in which I received the assistance of Mr. John Levack, a resident in the island, who supplies a separate list of Mosses and Lichens, noted by himself and other observers. The species of flowering plants and ferns, and their allies, are in number as follows:—

I. DICOTYLEDONES,	1. Thalamifloræ,	75
	2. Calycifloræ,	80
	3. Corollifloræ,	134
	4. Monochlamydeæ,	47
II. MONOCOTYLEDONES,	1. Floridæ or Petaloideæ,	40
	2. Glumiferæ,	74
		450
III. ACOTYLEDONES,	1. Equisetaceæ,	4
	2. Filices,	21
	3. Lycopodiaceæ,	3
		478

Mr. Levack's list of *Mosses*, includes 89 species; of *Lichens*, 29 species.

A list of *Algæ* found on the shores of Cumbrae, prepared by Mr. Roger Hennedy, was furnished to Dr. Balfour, and by him published in the *Transactions of the Edinburgh Botanical Society*, in 1856. The number of species then recorded was about 200. Subsequent observations by Mr. Hennedy, Mr. David Robertson, Mr. William Little, &c., have extended this number to 220.

The larger Cumbrae island is two miles west from Largs, four miles east from Bute, and one mile from the lesser island. It is of an irregular figure, three and a-half miles long from north-east to south-west; the average breadth is about two miles, and the circumference ten or eleven. The island consists of sandstone, probably of the old red series, and is remarkable for the number of its trap dykes. The highest of these traverses the island from the south-east to the north-west, and gives its peculiar outline to the larger Cumbrae. Similar eruptions of igneous rock are found crossing the island in all directions, and on the

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shore they are observed intermingling with each other, forming reticulations of a complex and singular description. The beds of sandstone are occasionally mixed with impure limestone. Two of the dykes rise prominently on the southern shore; one of them being 40 feet in height, 100 in length, and from 10 to 12 in thickness; the other, known as the "Lion," 200 feet in length, 70 to 80 in height, where it joins the ancient sea-wall, and from 12 to 15 feet in thickness. The latter dyke presents the appearance of an irregular mass of horizontal basaltic columns. The little island consists entirely of trap-rock, except at the small peninsula forming the site of the old castle, where a bed of sandstone is seen in section on the cliff, corresponding to the succession of sandstone and trap on the opposite shore of the mainland, at Hunterston and Portencross. The trap of the lesser island, especially in the neighbourhood of the lighthouse, frequently exhibits the columnar form.

The more interesting plants of both islands occur on the rocky shores, and amongst the cliffs over-looking the sea. The flora of the Cumbraes corresponds generally to that of the Island of Bute, and differs materially from the flora of Arran, which not only contains a subalpine vegetation, but exhibits on the shores a wider range and variety of genera and species. Some of the Cumbrae plants occupy a very limited area, and the present catalogue records several species which have disappeared within the last few years, and some which can scarcely be expected to survive a few more seasons. *Mertensia maritima*, common to the shores of Arran and Bute, was swept away from the sandy beach of Cumbrae by a storm. *Ranunculus sceleratus* has become extinct within a still more recent period. Last summer the only known station for *Geranium sanguineum* showed but a single plant left; this species, however, grows abundantly on the cliffs of the lesser island, equally beyond the incursions of the sea and the raids of rapacious botanists. *Anthemis nobilis* has been completely extirpated from its old habitat; and only a few plants are now known to maintain a precarious existence in the green-sward contiguous to the houses in the east end of Millport, where they are in danger of being speedily trodden down. *Senebiera Coronopus*, a rare plant in Scotland, disappeared last season from the shore, where it was overwhelmed with rubbish, and its only other observed station is on the exposed road side, close to several cottages in the west end of the village. *Eryngium maritimum* has been extirpated on the south side of the island, where it was at one time common, and now occurs principally on the sandy shore of the north side, along with the beautiful *Convolvulus Soldanella*, one of the

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botanical treasures of the island, which also occupies a narrowing space, and can be less spared. A single plant of *Symphytum officinale* has been seen for two seasons growing among rubbish, although a comparatively common species in the inland parts of the country. In the lesser Cumbrae, *Glaucium luteum*, the Horned Poppy, occurs sparingly on one part of the shore. The flora of the Cumbraes is not less remarkable for the variety of genera and species comprised within so limited an area, than for the absence of many of the commoner plants found on the neighbouring mainland. No species of *Papaver* has been observed even in the corn-fields; only one species of Geum (*urbanum*), although *G. intermedium* and *G. rivale* abound in the neighbourhood of Fairley, on the opposite coast; the only Saxifrage reported is the *hypnoides* (?) in the smaller island, no species of this genus occurring on the large Cumbrae; and numerous other desiderata will be observed on glancing over the catalogue. The list of brambles and willows might be considerably extended by the admission of varieties or doubtful species.

The island is rich in Ferns. Of the whole British species, exclusive of varieties, between 40 and 50 in number, Cumbrae yields 21 species. Several of these occur very sparingly, and the *furor* for fern-gathering having extended to others than botanists, and affected the fair sex more especially, the annual plunder of such species as *Asplenium marinum*, *A. Ruta-muraria* (now diminished to a few plants), *Botrychium Lunaria*, *Hymenophyllum Wilsoni*, *Lastrea Fœnisecii*, *Ophioglossum vulgatum*, and, above all, *Osmunda regalis*, which is carried off root and branch, in bags and baskets great and small, leaves little hope to the botanist that Cumbrae will for many years longer maintain its reputation for ferns.

Amongst introduced plants may be noted *Lavatera arborea*, the Tree Mallow (the Bass Mallow of the Frith of Forth), a biennial, attaining a considerable height in the kitchen gardens of the cottagers, and brought from Ailsa Craig, whence it has been abundantly propagated on the Ayrshire coast; *Archangelica officinalis*, an escape from gardens, and growing occasionally on the borders of fields, but noted in Hooker and Arnott's *British Flora* as nowhere in this country found truly wild; *Valeriana pyrenaica; Tragopogon porrifolius*, the Salsify, occurring in old gardens; *Lysimachia Nummularia*, long established in the lawn in front of Captain Miller's cottage; *Phalaris arundinacea*, *β variegata*, found growing in a ditch at a considerable distance from any dwelling; *Iris fœtidissima*, remarkable for its emitting, when bruised, the odour of roast beef. This plant has probably been introduced from England, of which it is a native, and flourishes in an inclosure behind

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the village, without cultivation, but exhibits no tendency to spread. *Draba muralis*, another English plant, has also found a habitation behind the village, and although seeding freely, appears to be confined to the limited spot where it has been introduced. It is a common spring weed in our Botanic Garden, but is not truly wild in any part of Scotland. *Lycium afrum*, the African box-thorn, popularly known as the "Duke of Argyle's tea-tree," has long been established in the walls of old gardens and fields, where it flowers freely. *Gagea lutea* occurs in the Kelburne woods on the opposite shore.

There is little natural wood in the island, nor do the peat-mosses give evidence of the existence of large trees at a former period. The only memorial of this description is the spreading root of a fir tree, measuring ten feet long by nine feet broad, and having a circumference of about thirty feet, exposed on the border of a small lake at the highest part of the island, on the north-west side. The trees in the neighbourhood of Millport were planted by the Earl of Glasgow about forty years ago, and extend, chiefly in the form of beltings, over 120 acres out of the 5,120 acres of the superficial area of the island.

CATALOGUE OF CUMBRAE PLANTS.

I.—PHANEROGAMEÆ (Flowering Plants).

CLASS I.—DICOTYLEDONES.

SUB-CLASS I.—THALAMIFLORÆ.

Ranunculaceæ.
Anemone, L.
nemorosa, L.
Caltha, L.
palustris, L.
Ranunculus, L.
acris, L.
aquatilis, L.
bulbosus, L.
Ficaria, L.
Flammula, L.
hederaceus, L.
repens, L.
sceleratus, L.

Berberidaceæ.
Berberis, L.
vulgaris, L.

Papaveraceæ.
Glaucium, Tourn.
luteum, Scop.

Fumariaceæ.
Corydalis, DC.
claviculata, DC.
Fumaria, L.
officinalis, L.

Cruciferæ.
Arabis, L.
hirsuta, Br.
Barbarea, Br.
vulgaris, Br.
Brassica, L.
monensis, Br.
Capsella, Vent.
Bursa-pastoris, DC.
Cardamine, L.
amara, L.
hirsuta, L.
pratensis, L.
Cheiranthus, L.
Cheiri, L.
Cochlearia, L.
officinalis, L.
Draba, L.
muralis, Br. (introduced.)
verna, L.
Nasturtium, Br.
officinale, Br.
Raphanus, L.
Raphanistrum, L.
Senebiera, DC.
Coronopus, Poiret.

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SUB-CLASS I.—THALAMIFLORÆ—*continued.*

Sinapis, L.
arvensis, L.
Sisymbrium, L.
officinale, L.
thalianum, Gaud.
Thlaspi, L.
arvense, L.

Violaceæ.

Viola, L.
canina, L.
β Curtisii, Forst.
tricolor, L.
β arvensis, Murr.

Droseraceæ.

Drosera, L.
rotundifolia, L.
Parnassia, L.
palustris, L.

Polygalaceæ.

Polygala, L.
vulgaris, L.

Caryophyllaceæ.

Cerastium, L.
glomeratum, Thuill. (vulgatum, L.)
tetrandrum, Curt.
triviale, Link. (viscosum, L.)
Honckenya, Ehrh.
peploides, Ehrh.
Lychnis, L.
diurna, Sibth. (dioica, L.)
Flos-cuculi, L.
Githago, Lam.
Mœhringia, L.
trinervis, Clairv.
Sagina, L.
nodosa, E. Mey.
procumbens, L.
subulata, Wimm.
Silene, L.
maritima, With.
Stellaria, L.
graminea, L.
Holostea, L.
media, With.
uliginosa, Murr.

Malvaceæ.

Lavatera, L.
arborea, L. (introduced.)
Malva, L.
sylvestris, L.

Tiliaceæ.

Tilia, L.
europæa, L.

Hypericaceæ.

Hypericum, L.
Androsæmum, L.
humifusum, L.
perforatum, L.
pulchrum, L.
quadrangulum, L.

Aceraceæ.

Acer, L.
campestre, L.
Pseudo-platanus, L.

Geraniaceæ.

Erodium, L'Herit.
cicutarium, Sm.
Geranium, L.
dissectum, L.
lucidum, L.
molle, L.
robertianum, L.
sanguineum, L.
sylvaticum, L.

Linaceæ.

Linum, L.
catharticum, L.
Radiola, Gmel.
Millegrana, Sm.

Oxalidaceæ.

Oxalis, L.
Acetosella, L.

SUB-CLASS II.—CALYCIFLORÆ.

Leguminosæ.

Anthyllis, L.
Vulneraria, L.
Lathyrus, L.
pratensis, L.
Lotus, L.
corniculatus, L.
major, Scop.
Ononis, L.
arvensis, L.
Sarothamnus, Wimm.
scoparius, Wimm.
Trifolium, L.
arvense, L.
filiforme, L.
minus, Sm.
pratense, L.
procumbens, L.
repens, L.
Ulex, L.
europæus, L.
Vicia, L.
Cracca, L.
hirsuta, Koch.
sativa, L.
β angustifolia.
sepium, L.

Rosaceæ.

Agrimonia, L.
Eupatoria, L.
Alchemilla, L.
arvensis, Scop.
vulgaris, L.
Comarum, L.
palustre, L.
Cratægus, L.
Oxyacantha, L.
Fragaria, L.
vesca, L.
Geum, L.
urbanum, L.
Potentilla, L.
anserina, L.
Fragariastrum, Ehrh.
Tormentilla, Nesl.
β reptans, L.
Prunus, L.
communis, Huds. (spinosa, L.)
Padus, L.
Pyrus, L.
aucuparia, Gært.
Rosa, L.
canina, L.
rubiginosa, L.
spinosissima, L.
Rubus, L.
corylifolius, Sm.
glandulosus, Bell.
Idæus, L.
suberectus, And.
fruticosus.
Spiræa, L.
Ulmaria, L.

Lythraceæ.

Lythrum, L.
Salicaria, L.
Peplis, L.
Portula, L.

Onagraceæ.

Circæa, L.
Lutetiana, L.
Epilobium, L.
montanum, L.
palustre, L.

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Sub-Class II.—CALYCIFLORÆ—*continued.*

Halorageaceæ.
Myriophyllum, L.
spicatum, L.

Portulacaceæ.
Montia, L.
fontana, L.

Paronychiaceæ.
Scleranthus, L.
annuus, L.
Spergula, L.
arvensis, L.
Spergularia.
rubra, Camb.

Crassulaceæ.
Cotyledon, L.
Umbilicus, L.
Sedum, L.
acre, L.
anglicum, Huds.
Telephium, L.

Saxifragaceæ.
Chrysosplenium, L.
oppositifolium, L.
Saxifraga hypnoides, L. (?)

Umbelliferæ.
Ægopodium, L.
Podagraria, L.
Æthusa, L.
Cynapium, L.
Angelica, L.
sylvestris, L.
Archangelica, L. (introduced.)
Anthriscus, Hoffm.
sylvestris, Hoffm.
Bunium, L.
flexuosum, With.
Carum, L.
verticillatum, Koch.
Conium, L.
maculatum, L.
Daucus, L.
Carota, L.
Eryngium, L.
maritimum, L.
Helosciadium, Koch.
inundatum, Koch.
nodiflorum, Koch.
Heracleum, L.
Sphondylium, L.
Hydrocotyle, L.
vulgaris, L.
Ligusticum, L.
scoticum, L.
Myrrhis, Tourn.
odorata, Scop.
Œnanthe, L.
crocata, L.
Lachenalii, Gmel.
Pimpinella, L.
Saxifraga, L.
Sanicula, L.
europæa, L.
Torilis, Adans.
Anthriscus, Gært.

Araliaceæ.
Adoxa, L.
Moschatellina, L.
Hedera, L.
Helix, L.

Sub-Class III.—COROLLIFLORÆ.

Caprifoliaceæ.
Lonicera, L.
Periclymenum, L.
Sambucus, L.
nigra, L.

Rubiaceæ.
Asperula, L.
odorata, L.
Galium, L.
Aparine, L.
palustre, L.
β Witheringii, Sm.
saxatile, L.
uliginosum, L.
verum, L.
Sherardia, L.
arvensis, L.

Valerianaceæ.
Valeriana, L.
officinalis, L.
pyrenaica, L. (introd.)
Valerianella, Mœnch.
olitoria, Mœnch.

Dipsacaceæ.
Scabiosa, L.
succisa, L.

Compositæ.
Achillæa, L.
Millefolium, L.
Ptarmica, L.
Antennaria, Br.
dioica, Gært.
Anthemis, L.
nobilis, L.
Apargia, Schreb.
autumnalis, Willd.
Arctium, L.
Lappa, L.
Artemisia, L.
vulgaris, L.
Aster, L.
Tripolium, L.
Bellis, L.
perennis, L.
Bidens, L.
tripartita, L.
Carduus, L.
arvensis, Curt.
lanceolatus, L.
palustris, L.
Centaurea, L.
nigra, L.
Chrysanthemum, L.
Leucanthemum, L.
segetum, L.
Crepis, L.
paludosa, Mœnch.
Crepis, L.
virens, L.
Doronicum, L.
Pardalianches, L.
Eupatorium, L.
cannabinum, L.
Filago, L.
germanica, L.
Gnaphalium, L.
sylvaticum, L.
uliginosum, L.
Hieracium, L.
murorum, L.
Pilosella, L.
sylvaticum, Sm.
Hypochæris, L.
radicata, L.
Lapsana, L.
communis, L.
Leontodon, L.
Taraxacum, L.
Matricaria, L.
inodora, L.
maritima, L.
Parthenium, L.
Petasites, Gært.
vulgaris, Desf.
Senecio, L.
aquaticus, Huds.
Jacobæa, L.
sylvaticus, L.

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Sub-Class III.—COROLLIFLORÆ—*continued.*

Senecio, L.
    vulgaris, L.
Solidago, L.
    Virgaurea, L.
Sonchus, L.
    arvensis, L.
    oleraceus, L.
Tanacetum, L.
    vulgare, L.
Tragopogon, L.
    porrifolius, L. (introd.)
Tussilago, L.
    Farfara, L.

Campanulaceæ.

Campanula, L.
    rotundifolia, L.
Jasione, L.
    montana, L.

Ericaceæ.

Calluna, Salisb.
    vulgaris, Salisb.
Erica, L.
    cinerea, L.
    Tetralix, L.
Pyrola, L.
    media, Sw.

Vacciniaceæ.

Vaccinium, L.
    Myrtillus, L.

Aquifoliaceæ.

Ilex, L.
    Aquifolium, L.

Oleaceæ.

Fraxinus, L.
    excelsior L.
Ligustrum, L.
    vulgare, L.

Gentianaceæ.

Erythræa, Reneal.
    Centaurium, Pers.
    littoralis, Fr.
Gentiana, L.
    campestris, L.
Menyanthes, L.
    trifoliata, L.

Convolvulaceæ.

Convolvulus, L.
    sepium, L.
    Soldanella, L.

Boraginaceæ.

Lycopsis, L.
    arvensis, L.
Mertensia, Roth.
    maritima, Don.
Myosotis, L.
    arvensis, Hoffm.
    cæspitosa, Schultz.
    palustris, Roth.
    repens, Don.
    versicolor, Lehm.
Symphytum, L.
    officinale, L.

Solanaceæ.

Solanum, L.
    Dulcamara, L.

Scrophulariaceæ.

Digitalis, L.
    purpurea, L.
Euphrasia, L.
    Odontites, L.
    officinalis, L.
Linaria, Juss.
    vulgaris, Mœnch.
Melampyrum, L.
    pratense, L.
Pedicularis, L.
    palustris, L.
    sylvatica, L.
Rhinanthus, L.
    Crista-galli, L.
Scrophularia, L.
    nodosa, L.
Verbascum, L.
    Thapsus, L.
Veronica, L.
    agrestis, L.
    Anagallis, L.
    arvensis, L.
    Beccabunga, L.
    Chamædrys, L.
    officinalis, L.
    scutellata, L.
    serpyllifolia, L.

Labiatæ.

Ajuga, L.
    reptans, L.
Galeopsis, L.
    Tetrahit, L.
    versicolor, Curt.
Lamium, L.
    intermedium, Fries.
Lamium, L.
    purpureum, L.
Lycopus, L.
    europæus, L.
Mentha, L.
    aquatica, L.
    arvensis, L.
Nepeta, L.
    Glechoma, Benth.
Scutellaria, L.
    galericulata, L.
Stachys, L.
    arvensis, L.
    palustris, L.
    β ambigua, Sm.
    sylvatica, L.
Teucrium, L.
    Scorodonia, L.
Thymus, L.
    serpyllum, L.

Lentibulariaceæ.

Pinguicula, L.
    lusitanica, L.
    vulgaris, L.
Utricularia, L.
    minor, L.
    vulgaris, L.

Primulaceæ.

Anagallis, L.
    arvensis, L.
    tenella, L.
Glaux, L.
    maritima, L.
Lysimachia, L.
    nemorum, L.
    Nummularia, L. (introduced.)
Primula, L.
    vulgaris, Huds.
Samolus, L.
    Valerandi, L.

Plumbaginaceæ.

Armeria, Willd.
    maritima, Willd.

Plantaginaceæ.

Littorella, L.
    lacustris, L.
Plantago, L.
    Coronopus, L.
    lanceolata, L.
    major, L.
    maritima, L.

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SUB-CLASS IV.—MONOCHLAMYDEÆ.

A. ANGIOSPERMÆ.

Chenopodiaceæ.

Atriplex, L.
- angustifolia, Sm.
- laciniata, Bab.
- rosea, Bab.
- erecta, Huds.
- hastata, L. (patula, S.)

Chenopodium, L.
- album, L.
- β viride, L.

Salicornia, L.
- herbacea, L.

Salsola, L.
- Kali, L.

Suæda, Forsk.
- maritima, Dumort.

Polygonaceæ.

Polygonum, L.
- amphibium, L.
- β terrestre.
- aviculare, L.
- Bistorta, L.
- Convolvulus, L.
- Hydropiper, L.
- lapathifolium, L.

Polygonum, L.
- Persicaria, L.
- Raii, Bab.

Rumex, L.
- acetosa, L.
- Acetosella, L.
- crispus, L.
- obtusifolius, L.
- viridis, Sibth.

Empetraceæ.

Empetrum, L.
- nigrum, L.

Euphorbiaceæ.

Euphorbia, L.
- helioscopia, L.
- Peplus, L.

Mercurialis, L.
- perennis, L.

Urticaceæ.

Ulmus, L.
- montana, L.

Urtica, L.
- dioica, L.
- urens, L.

Callitrichaceæ.

Callitriche, L.
- verna, L.
- pedunculata, DC., β sessilis.

Amentiferæ.

Alnus, Tourn,
- glutinosa, Gært.

Betula, L.
- alba, L.

Corylus, L.
- Avellana, L.

Fagus, L.
- sylvatica, L.

Myrica, L.
- Gale, L.

Populus, L.
- tremula, L.

Quercus, L.
- Robur, L.

Salix, L.
- ambigua, Ehrh.
- aurita, L.
- fusca, L.
- pentandra, L.
- viminalis, L.

B. GYMNOSPERMÆ.

Coniferæ.

Juniperus, L.
- communis, L.

Pinus, L.
- sylvestris, L.

CLASS II.—MONOCOTYLEDONES.

SUB-CLASS.—FLORIDÆ OR PETALOIDEÆ.

Orchidaceæ.

Gymnadenia, Br.
- conopsea, Br.

Habenaria, Br.
- bifolia, Bab.
- chlorantha, Bab.
- viridis, Br.

Listera, Br.
- cordata, Br.
- ovata, Br.

Orchis, L.
- latifolia, L.
- maculata, L.
- mascula, L.

Iridaceæ.

Iris, L.
- fœtidissima, L. (introduced.)
- Pseudacorus, L.

Liliaceæ.

Allium, L.
- vineale, L.

Agraphis, Link.
- nutans.

Juncaceæ.

Juncus, L.
- acutiflorus, Ehrh.
- bufonius, L.
- compressus, Jacq.
- conglomeratus, L.
- effusus, L.
- lamprocarpus, Ehrh.
- maritimus, Lam.
- squarrosus, L.
- supinus, Mœnch. (uliginosus, Sibth.

Luzula, DC.
- campestris, Br.

Luzula, DC.
- pilosa, Willd.
- sylvatica, Bich.

Narthecium, Huds.
- ossifragum, Huds.

Alismaceæ.

Alisma, L.
- Plantago, L.
- ranunculoides, L.

Triglochin, L.
- maritimum, L.
- palustre, L.

Typhaceæ.

Sparganium, L.
- nataus, L.
- ramosnm, Huds.
- simplex, Huds.

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Sub-Class.—FLORIDÆ or PETALOIDEÆ—*continued.*

Lemnaceæ.
Lemna, L.
minor, L.

Naiadaceæ.
Potamogeton, L.
natans, L.
oblongus, Viv.
Zostera, L.
marina, L.
angustifolia.

Sub-Class.—GLUMIFERÆ.

Cyperaceæ.
Carex, L.
acuta, L.
ampullacea, Good.
arenaria, L.
binervis, Sm.
cæspitosa, L.
extensa, Good.
flava, L.
fulva, Good.
glauca, Scop.
hirta, L.
muricata, L.
ovalis, Good.
paludosa, Good.
panicea, L.
paniculata, L.
præcox, Jacq.
pulicaris, L.
remota, L.
stellulata, Good.
sylvatica, Huds.
vulgaris, Fries.
vulpina, L.
Eleocharis, Br.
palustris, Br.
uniglumis, Link.
Isolepis, R. Br.
fluitans.
setacea.
Eriophorum, L.
angustifolium, Roth.
Schœnus, L.
nigricans, L.
Scirpus, L.
cæspistosus, L.
maritimus, L.

Gramineæ.
Agrostis, L.
alba, L.
canina, L.
vulgaris, With.
Aira, L.
cæspitosa, L.
caryophyllea, L.
flexuosa, L.
præcox, L.
Alopecurus, L.
geniculatus, L.
pratensis, L.
Ammophila, Host.
arundinacea, Host.
Anthoxanthum, L.
odoratum, L.
Arrhenatherum, P. B.
avenaceum, Beauv.
β bulbosum, Lindl.
Bromus, L.
asper, Murr.
sterilis, L.
Catabrosa, Beauv.
aquatica, Beauv.
β minor.
Cynosurus, L.
cristatus, L. (var. vivipara.)
Dactylis, L.
glomerata, L.
Festuca, L.
arundinacea, Schreb.
bromoides, L.
ovina, L. (var. vivipara.)
pratensis, Huds.
Glyceria, Br.
fluitans, Br.
Holcus, L.
lanatus, L.
mollis, L.
Lolium, L.
perenne, L.
Melica, L.
uniflora, L.
Molinia, Schrk.
cærulea, Mœnch.
Nardus, L.
stricta, L.
Phalaris, L.
arundinacea, L.
β variegata.
Phragmites, Trin.
communis, Trin.
Poa, L.
annua, L.
nemoralis, L.
pratensis, L.
trivialis, L.
Psamma, Beauv.
arenaria, Beauv.
Sclerochloa, Br.
maritima, Bab.
Serrafalcus, Parl.
mollis, Parl.
Sesleria, Scop.
cærulea, Scop.
Triodia, R. Br.
decumbens, Beauv.
Triticum, L.
junceum, L.
laxum, Fries.
repens, L.

II.—CRYPTOGAMEÆ (Flowerless Plants.)

CLASS III.—ACOTYLEDONES.

Sub-Class.—ACROGENÆ.

Equisetaceæ.
Equisetum, L.
arvense, L.
limosum, L.
palustre, L.
sylvaticum, L.

Filices (Ferns).
Asplenium, L.
Adiantum-nigrum, L.
marinum, L.
Ruta-muraria, L.
Trichomanes, L.
Asplenium, L.
Filix-fœmina, Roth.
Blechnum, L.
boreale, Willd.
Botrychium, Sw.
Lunaria, Sw.

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Sub-Class.—ACROGENÆ—*continued.*

Hymenophyllum, Sm.
Wilsoni, Hook.

Lastrea, Bory.
Filix-mas, Presl.
Fœnisecii, Wats.
Oreopteris, Presl.
dilatata, Presl.

Ophioglossum, L.
vulgatum, L.

Osmunda, L.
regalis, L.

Polypodium, L.
Phegopteris, L.
vulgare, L.

Polystichum, Roth.
aculeatum, Roth.
angulare, Newm.
β lobatum.

Pteris, L.
aquilina, L.

Scolopendrium, Sm.
vulgare, Sym.

Lycopodiaceæ.

Lycopodium, L.
clavatum, L.
selaginoides, L.
Selago, L.

BRYACEÆ or MUSCI (MOSSES).—J. L.

Phascum subulatum.
Sphagnum obtusifolium.
squarrossum.
acutifolium.
cuspidatum.
Gymnostomum truncatulum.
tenue.
Anœctangium ciliatum.
Splachnum ampullaceum.
Weissia controversa.
Grimmia apocarpa.
maritima.
pulvinata.
Didymodon purpureus.
nervosus.
Trichostomum lanuginosum.
canescens.
heterostichum
aciculare.
polyphyllum.
Dicranum bryoides.
adiantoides.
taxifolium.
flexuosum.
undulatum.
scoparium.
heteromallum.
Tortula muralis.
Tortula ruralis.
unguiculata.
Polytrichum undulatum.
piliferum.
juniperinum.
commune.
alpinum.
urnigerum.
aloides.
nanum.
Entosthodon Templetoni.
Funaria hygrometrica.
Orthotrichum rupincola.
crispum.
Bryum capillare.
ventricosum.
roseum.
ligulatum.
punctatum.
rostratum.
hornum.
Bartramia pomiformis.
fontana.
Fontinalis antipyretica.
Hookeria lucens.
Hypnum trichomanoides.
complanatum.
Hypnum denticulatum.
purum.
piliferum.
plumosum.
rufescens.
polyanthos.
sericeum.
alopecurum.
dendroides.
myosuroides.
splendens.
proliferum.
prælongum.
rutabulum.
velutinum.
ruscifolium.
striatum.
cuspidatum.
stellatum.
triquetrum.
squarrosum.
fluitans.
aduncum.
commutatum.
scorpioides.
cupressiforme.
molluscum.

LICHENACEÆ (LICHENS).—J. L.

Opegrapha scripta.
serpentina.
Lecidea geographica.
ferruginea.
Lecanora atra.
tartarea.
Parmelia glomulifera.
caperata.
saxatilis.
omphalodes.
Parmelia herbacea.
pulverulenta.
steilaris.
parietina.
physodes.
Sticta pulmonaria.
Cetraria glauca.
Evernia prunastri.
Ramalina fastigiata.
farinacea.
Sphærophoron coralloides.
compressum.
Stereocaulon paschale.
Cladonia rangiferina.
furcata.
Scyphophorus cæspititius.
pyxidatus.
cocciferus.
Placodium plumbeum.

ALGACEÆ or ALGÆ (SEAWEEDS).—R. H., D. R., &c.

Halidrys siliquosa, Lyngbye.
Fucus vesiculosus, Linnæus.
var. balticus.
Fucus ceranoides, Linnæus.
serratus, Linnæus.
nodosus, Linnæus.

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ALGACEÆ OR ALGÆ (SEAWEEDS)—*continued.*

Fucus canaliculatus, Linnæus.
Himanthalia lorea, Lyngbye.
Desmarestia aculeata, Linnæus.
viridis, Müller.
Arthrocladia villosa, Hudson.
Sporochnus pedunculatus, Hudson.
Alaria esculenta, Linnæus.
Laminaria digitata, Linnæus.
bulbosa, Hudson.
saccharina, Linnæus.
Phyllitis, Linnæus.
fascia, Müller.
Chorda filum, Linnæus.
lomentaria, Linnæus.
Cutleria multifida, Smith.
Zonaria parvula, Greville.
Dictyota dichotoma, Hudson.
intricata, Greville.
Stilophora rhizoides, Ehrenberg.
Lyngbyæi, J. Agardh.
Dictyosiphon fœniculaceus, Hudson.
Striaria attenuata, Greville.
fragilis, J. Agardh.
Punctaria latifolia, Greville.
plantaginea, Roth.
tenuissima, Greville.
Asperococcus Turneri, Dillwyn.
echinatus, Mertens.
Litosiphon pusillus, Carmichael.
Laminariæ, Lyngbye.
Chordaria flagelliformis, Müller.
Mesogloia vermicularis, Agardh.
virescens, Carmichael.
Leathesia tuberiformis, Smith.
crispa, Harvey.
Ralfsia verrucosa, Aresch.
Elachista fucicola, Velley.
stellulata, Griffiths.
Grevillii.
Myrionema strangulans, Greville.
Leclancherii, Chauv.
punctiforme, Lyngbye.
Cladostephus verticillatus, Lightfoot.
spongiosus, Hudson.
Sphacelaria scoparia, Linnæus.
plumosa, Lyngbye.
cirrhosa, Roth.
radicans, Dillwyn.
racemosa, Greville.
Ectocarpus siliculosus, Lyngbye.
Hincksiæ, Harvey.
tomentosus, Hudson.
crinitus, Carmichael.
distortus, Carmichael.
Landsburgii, Harvey.
litoralis, Linnæus.
granulosus, var. tessellatus, Haydn.
sphærophorus, Carmichael
brachiatus, Harvey,
Ectocarpus Mertensii, Turner
Myriotrichia clavæformis, Harvey.
filiformis, Harvey.
Odonthalia dentata, Linnæus.
Rhodomela lycopodioides, Linnæus.
subfusca, Woodward.
Polysiphonia urceolata, Smith.
formosa, Suhr.
fibrata, Dillwyn.
elongella, Harvey.
elongáta, Hudson.
violacea, Agardh.
fibrillosa, Dillwyn.
Brodiæi, Dillwyn.
nigrescens, Hudson.
atro-rubescens, Dillwyn.
fastigiata, Roth.
parasitica, Hudson.
byssoides, Good. & Woodw.
Dasya coccinea, Hudson.
Bonnemaisonia asparagoides, Woodward.
Laurencia pinnatifida, Gmelin.
cæspitosa, Lamour.
Chondria dasyphylla, Woodward.
Lomentaria kaliformis, Good. & Woodw.
Catenella opuntia, Good. & Woodward.
Chylocladia clavellosa, Turner.
articulata, Hudson.
Champia parvula, Agardh.
Corallina officinalis, Linnæus.
Jania rubens, Linnæus.
Melobesia polymorpha, Linnæus.
fasciculata, Lamark.
membranacea, Lamour.
verrucata, Lamour.
pustulata, Lamour.
Hildenbrandtia rubra, Meneg.
Lithocystis Allmanni, Harvey.
Wormskioldia (Delesseria) sanguinea, Linn.
sinuosa, Good. & Woodward.
alata, Hudson.
Hypoglossum, Woodward.
ruscifolia, Turner.
Nitophyllum punctatum, With.
Bonnemaisoni, Agardh.
laceratum, Gmelin.
Plocamium coccineum, Hudson.
Rhodophyllis bifida, Good. & Woodward.
Callophyllis laciniata, Hudson.
Calliblepharis jubata, Good. & Woodward.
Rhodymenia palmata, Linnæus.
Sphærococcus coronopifolius, Good. & Woodw.
Gracilaria confervoides, Linnæus.
Cystoclonium purpurascens, Hudson.
Gelidium corneum, Hudson.
Gigartina mamillosa, Good. & Woodward.
Chondrus crispus, Linnæus.
Phyllophora rubens, Linnæus.
membranifolius, Good. & Woodw
Brodiæi, Turner.

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ALGACEÆ OR ALGÆ (SEAWEEDS)—*continued.*

Peyssonella Dubyi, Cronan.
Ahnfeldtia plicata, Hudson.
Polyides rotundus, Gmelin.
Furcellaria fastigiata, Hudson.
Dumontia filiformis, Fl. Danica.
Halymenia ligulata, Woodward.
Scinaia furcellata, Turner.
Schizymenia edulis, Stackh.
Cruoria Arnottii.
Actinococcus Hennedyi, Harv.
Gloiosiphonia capillaris, Hudson.
Dudresnaia coccinea, Agardh.
Hudsoni.
Ptilota plumosa, Linnæus.
elegans, Bonnemaison.
Ceramium rubrum, Hudson.
botryocarpum, Griffiths.
decurrens, Kützing.
Deslongchampsii, Chauv.
strictum, Kützing.
nodosum, Kützing.
flabelligerum, J. Agardh.
echionotum, J. Agardh.
acanthonotum, Carmichael.
ciliatum, Ellis.
Griffithsia equisetifolia, Lightfoot.
corallina, Linnæus.
setacea, Ellis.
Wrangelia multifida, Hudson.
Callithamnion plumula, Ellis.
Turneri, Dillwyn.
tetragonum, With.
Hookeri, Dillwyn.
roseum, Smith.
byssoideum, Arnot.
polyspermum, Agardh.
corymbosum, Smith.
Rothii, Linnæus.
floridulum, Dillwyn.
virgatulum, Harvey.
Daviesii, Smith.
Corynespora pedicellata, J. Agardh.
Codium tomentosum, Hudson.
Bryopsis plumosa, Hudson.
Vaucheria velutina, Agardh.
Cladophora rupestris, Linnæus.
lætevirens, Dillwyn.
refracta, Agardh.
Cladophora albida, Hudson.
lanosa, Roth.
arcta, Dillwyn.
flavescens, Roth.
fracta, Fl. Danica.
Rhizoclonium riparium, Roth.
Conferva litorea, Harvey.
tortuosa, Dillwyn.
implexa, Dillwyn.
melagonium, Web & Mohr.
ærea, Dillwyn.
Youngana, Dillwyn.
Enteromorpha intestinalis, Linnæus.
compressa, Linnæus.
erecta, Lyngbye.
ramulosa, Smith.
percursa, Agardh.
Ulva latissima, Linnæus.
Lactuca, Linnæus.
Linza, Linnæus.
Porphyra laciniata, Lightfoot.
vulgaris, Agardh.
Bangia fusco-purpurea, Dillwyn.
ceramicola, Lyngbe.
carnea, Dillwyn.
Rivularia plicata, Carmichael.
atra, Roth.
Schizosiphon Warreniæ.
Calothrix confervicola, Agardh.
luteola, Greville.
scopulorum, Web & Mohr.
fasciculata, Agardh.
pannosa, Agardh.
hydnoides, Carmichael.
Lyngbya majuscula, Dillwyn.
Carmichaelii, Harvey.
speciosa, Carmichael.
Microcoleus anguiformis, Harvey.
Oscillatoria littoralis, Carmichael.
subuliformis, Thwaites.
insignis, Thwaites.
Spirulina tenuissima, Kützing.
Hutchinsiæ, Kützing.
Monormia intricata, Berkeley.
Sphærozyga Thwaitesii, Harvey.
Broomei, Thwaites.
Spermoseira litorea, Kützing.

The climate of Cumbrae is salubrious and mild, as will appear from the table of thermometrical observations for 1681, obligingly furnished by Captain Miller, along with the registrations of his rain-gauge for the same year. The island has a less amount of rain-fall than the Largs coast, where the hills more readily attract the clouds drifting from Arran; and the pleasant village of Millport—a favourite resort of the citizens of Glasgow—is sheltered by its position from all the prevailing winds, excepting the south-west. The inordinate amount of rain on the west coast last summer will render the season of 1861 somewhat

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memorable. From the following Table it appears that the excessive rain-fall was in a great measure peculiar to the west of Scotland. Of nine different stations, representing the east, north, central, and western districts, it will be observed that the quantity of rain was in excess chiefly, and in the order stated, in Glasgow, Cumbrae, Paisley, Bute, Greenock, and Largs.*

TABLE I.—COMPARATIVE RAIN-FALL IN JULY, AUGUST, AND SEPTEMBER, 1861, IN DIFFERENT PARTS OF SCOTLAND.

	July.	August.	September.	Total.
Edinburgh,...............	2·51	3·07	4·26	9·84
Aberdeen, ...	2·35	4·50	4·00	10·85
Perth,.....................	4·06	5·47	5·24	14·77
Glasgow, ...	5·71	8·33	3·74	17·78
Cumbrae (Millport),....	4·00	9·30	4·80	18·10
Paisley, ...	3·65	10·50	5·85	20·00
Bute, ...	4·10	10·50	6·30	20·90
Greenock, ...	3·85	11·15	7·10	22·10
Largs,......................	3·90	12·70	6·00	22·60

TABLE II.—RAIN-FALL AT GREENOCK, BRISBANE GLEN, LARGS, AND CUMBRAE, FOR THE YEAR 1861.

Greenock.		Brisbane.		Larga.		Cumbrae.	
January,......	6	January, ...	5·60	January, ...	4·30	January,......	4·30
February, ...	4·90	February, ...	3·50	February, ...	3·10	February,....	2·20
March,........	9·62	March, ...	6·85	March, ...	6·60	March,........	5·70
April,.........	0·45	April, ...	0·60	April,.........	0·50	April,.........	0·20
May, ...	1·67	May,..........	1·90	May,..........	1·60	May, ...	1·50
June, ...	3·90	June, ...	3·60	June, ...	3·30	June, ...	2·50
July,.........	3 85	July,..........	3·90	July,..........	3·50	July, ...	4·00
August, ...	11·15	August, ...	12·70	August, ...	11·20	August, ...	9·30
September,...	7·10	September,...	6·00	September,...	5·50	September, ...	4·80
October,......	5·85	October,......	5·15	October,......	4·90	October,......	4·30
November,.....	9·30	November,...	8·10	November,...	7·20	November,...	5·10
December, ...	5·35	December, ...	4·10	December, ...	4·10	December, ...	3·30
Total,...	69·14	Total,...	62·0	Total,...	55·80	Total,...	47·20

* The mean depth of rain for the whole country during the month of August was, in inches, 6·57; being $3\frac{3}{4}$ inches above the average, or considerably more than double. The mean depth at places in the west was 9·45; in the east, 4·31. The mean number of days on which rain fell was 25 in the west and 20 in the east. The greatest depths are recorded at Tarbet, 21·25 inches; Tyndrum, 17·10; Portree, 15·21; Stronvar, 12·85; and Balloch Castle, 12·11: the least at Thurston, 2·10; and generally at stations south of the Forth. The greatest individual falls were, Wanlockhead, 1·49 inches on the 11th, 2·91 on the 18th; Paisley, 2·22 on the 12th; Portree, 1·80 on the 25th; and Douglas Castle, 1·70 on the 12th.

During the three months of July, August, and September, the rain-fall at Tarbet, on Lochlomond, was 41·09 inches; Portree, in Skye, 38·03 inches; Tyndrum, 33·70 inches; Stronvar, on Loch Voil, 26·00 inches; and Wanlockhead, 25·67 inches.—*Report of Meteorological Society of Scotland.*

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TABLE III.—TEMPERATURE AND FALL OF RAIN AT THE ISLAND OF CUMBRAE FOR THE YEAR 1861.

Latitude 55° 47′ *North, Longitude* 5° *West; Observation above the Sea,* 50 *feet.* (JAMES MILLER, ESQ.)

Days of Month.	January. Thermometer.		January. Rain-fall.	February. Thermometer.		February. Rain-fall.	March. Thermometer.		March. Rain-fall.	April. Thermometer.		April. Rain-fall.	May. Thermometer.		May. Rain-fall.	June. Thermometer.		June. Rain-fall.	Days of Month.
	Highest.	Lowest.	Inches.	Highest.	Lowest.	Inches.	Highest.	Lowest.	Inches.	Highest.	Lowest.	Inches.	Highest.	Lowest.	Inches.	Highest.	Lowest.	Inches.	
1	36°	29°	...	...	...	...	45°	35°	...	50°	46°	...	58°	46°	...	59°	50°	$\frac{2}{10}$	1
2	38	32	...	...	...	...	45	32	$\frac{4}{10}$	52	42	...	57	49	...	61	49	$\frac{4}{10}$	2
3	38	25	...	...	...	...	45	32	...	50	41	...	59	38	...	61	50	...	3
4	32	25	...	...	...	...	43	35	$\frac{6}{10}$	50	40	$\frac{2}{10}$	57	44	...	70	52	...	4
5	32	28	...	...	...	...	52	44	$\frac{8}{10}$	52	38	...	57	41	...	66	49	...	5
6	32	21	...	...	...	...	49	35	$1\frac{1}{10}$	52	38	...	59	44	...	66	51	...	6
7	33	21	...	...	...	...	46	43	$1\frac{3}{10}$	52	37	...	52	34	...	71	51	...	7
8	36	35	...	...	...	...	48	38	...	51	38	...	49	36	...	66	50	...	8
9	42	34	$\frac{8}{10}$	...	...	...	50	41	$1\frac{5}{10}$	50	43	...	49	32	...	67	51	...	9
10	40	36	$\frac{9}{10}$	...	...	...	47	31	$1\frac{7}{10}$	51	45	...	53	33	...	58	49	$\frac{5}{10}$	10
11	47	37	1	33°	27°	...	45	34	2	53	37	...	58	39	...	62	53	...	11
12	42	32	$1\frac{7}{10}$	35	25	...	44	36	$2\frac{1}{10}$	57	40	...	54	35	...	62	54	$\frac{9}{10}$	12
13	37	30	$1\frac{9}{10}$	34	31	...	45	40	...	57	40	...	55	45	$\frac{2}{10}$	68	56	1	13
14	38	33	...	42	35	...	47	39	...	55	41	...	59	48	...	76	59	...	14
15	37	30	...	43	38	...	46	39	$2\frac{5}{10}$	55	42	...	59	50	...	75	60	...	15
16	40	30	...	45	43	...	39	38	$2\frac{7}{10}$	54	38	...	61	52	...	67	52	...	16
17	38	35	...	49	41	...	42	39	$3\frac{1}{10}$	55	39	...	62	47	...	66	54	...	17
18	40	36	...	46	40	...	45	37	$3\frac{3}{10}$	60	43	...	62	43	...	71	54	...	18
19	45	42	...	46	40	...	47	40	$3\frac{4}{10}$	52	45	...	64	51	...	75	54	...	19
20	47	45	...	45	40	...	45	34	$3\frac{6}{10}$	57	46	...	64	51	...	70	59	...	20
21*	...	...	...	47	35	...	45	40	$3\frac{9}{10}$	52	38	...	55	52	$\frac{6}{10}$	72	56	...	21
22	...	...	...	45	36	...	49	44	4	55	40	...	61	53	$\frac{7}{10}$	74	54	$1\frac{4}{10}$	22
23	...	...	...	49	36	...	48	40	$4\frac{1}{10}$	55	42	...	57	52	$\frac{8}{10}$	65	55	$1\frac{6}{10}$	23
24	...	...	...	47	32	...	50	39	...	55	48	...	58	49	$\frac{9}{10}$	70	56	$1\frac{7}{10}$	24
25	...	...	...	45	35	...	47	42	...	57	44	...	61	48	1	64	52	$2\frac{1}{10}$	25
26	...	...	...	45	41	...	48	42	$4\frac{6}{10}$	55	37	...	62	47	...	65	53	...	26
27	...	...	...	45	39	...	50	40	...	50	39	...	59	42	...	72	53	...	27
28	...	...	...	46	38	$2\frac{2}{10}$	50	40	$5\frac{2}{10}$	52	34	...	65	51	...	65	54	$2\frac{5}{10}$	28
29	...	...	...	...	...	...	47	40	$5\frac{5}{10}$	52	44	...	61	51	$1\frac{2}{10}$	62	51	...	29
30	...	...	...	...	...	...	47	38	$5\frac{7}{10}$	57	45	...	62	50	...	61	52	...	30
31	...	...	...	...	...	...	47	42	...	...	...	...	62	51	$1\frac{5}{10}$	...	...	...	31

* House shut up from this date till the 9th February.—Fall of rain this month (January) was $4\frac{3}{10}$.

TABLE III.—TEMPERATURE AND FALL OF RAIN AT THE ISLAND OF CUMBRAE FOR THE YEAR 1861—*continued.*

Days of Month.	July. Thermometer.		July. Rain-fall.	August. Thermometer.		August. Rain-fall.	September. Thermometer.		September. Rain-fall.	October. Thermometer.		October. Rain-fall.	November. Thermometer.		November. Rain-fall.	December. Thermometer.		December. Rain-fall.	Days of Month.
	Highest.	Lowest.	Inches.	Highest.	Lowest.	Inches.	Highest.	Lowest.	Inches.	Highest.	Lowest.	Inches.	Highest.	Lowest.	Inches.	Highest.	Lowest.	Inches.	
1	62°	52°	$\frac{1}{10}$	68°	56°	...	63°	53°	...	58°	52°	...	44°	36°	...	41°	39°	...	1
2	60	52	...	64	55	$\frac{8}{10}$	64	55	...	57	47½	$\frac{1}{10}$	45	37	...	46	31	...	2
3	61	52	...	61	55	2	63	55	$\frac{2}{10}$	58	45	...	46	43	...	49	47	$\frac{2}{10}$	3
4	62	50	...	69	57	$2\frac{1}{10}$	62	54	$\frac{4}{10}$	57	51½	...	52	47	$\frac{3}{10}$	47	45	...	4
5	68	55	$\frac{4}{10}$	65	55	$2\frac{5}{10}$	62	53	$\frac{6}{10}$	56	51	$1\frac{1}{10}$	49	39	$\frac{4}{10}$	44	39	$\frac{8}{10}$	5
6	69	51	...	65	57	...	62	54	$\frac{8}{10}$	56	50	...	47	37	...	40	35	...	6
7	65	55	$1\frac{4}{10}$	60	57	$2\frac{9}{10}$	60	50	$\frac{9}{10}$	59	54	...	44	38	...	47	39	$1\frac{2}{10}$	7
8	66	54	...	64	56	$3\frac{6}{10}$	58	53	$1\frac{1}{10}$	57	52	...	45	31	$\frac{5}{10}$	45	42	$1\frac{4}{10}$	8
9	65	49	...	64	56	$3\frac{7}{10}$	61	53	...	57	47½	$1\frac{5}{10}$	40	34	...	45	37	$1\frac{7}{10}$	9
10	58	46	$1\frac{6}{10}$	66	56	$4\frac{2}{10}$	61	49	...	59	54	...	40	35	$\frac{6}{10}$	47	41	$1\frac{9}{10}$	10
11	64	47	$1\frac{7}{10}$	66	54	$4\frac{6}{10}$	65	54	...	63	52	$1\frac{6}{10}$	42	34	$\frac{8}{10}$	49	43	$2\frac{4}{10}$	11
12	68	54	...	66	54	$5\frac{6}{10}$	62	56	$1\frac{2}{10}$	59	57	$1\frac{7}{10}$	45	39	$\frac{9}{10}$	52	46	$2\frac{7}{10}$	12
13	62	54	$1\frac{8}{10}$	63	50	...	60	54	$1\frac{6}{10}$	61	53	2	44	37	...	49	48	$3\frac{1}{10}$	13
14	69	52	...	60	56	...	58	52	...	61	51½	...	44	37	1	49	45	$3\frac{2}{10}$	14
15	60	50	...	68	54	$6\frac{1}{10}$	60	51	...	54	43	$2\frac{1}{10}$	41	32	...	49	42	...	15
16	64	54	$1\frac{9}{10}$	64	54	$6\frac{2}{10}$	60	51	...	55	46	...	39	33	...	49	48	$3\frac{3}{10}$	16
17	62	50	$2\frac{4}{10}$	64	55	$6\frac{4}{10}$	60	51	...	55	45	...	39	30	...	50	46	...	17
18	62	50	$2\frac{5}{10}$	62	53	$7\frac{7}{10}$	66	50	$1\frac{7}{10}$	54	49	...	45	42	...	44	42	...	18
19	65	48	...	62	53	$7\frac{9}{10}$	60	51	...	54	52	...	52	48	$1\frac{3}{10}$	39	32	...	19
20	61	55	...	61	52	...	59	51½	2	57	52	$2\frac{6}{10}$	52	46	$1\frac{8}{10}$	44	36	...	20
21	70	56	$2\frac{6}{10}$	62	53	...	62	51½	$2\frac{1}{10}$	56	52	...	52	38	...	48	44	...	21
22	66	54	$2\frac{8}{10}$	60	54	$8\frac{5}{10}$	61	47	...	58	53	$3\frac{3}{10}$	42	32	$2\frac{4}{10}$	43	35	...	22
23	65	54	3	62	51	$8\frac{7}{10}$	55	49½	$3\frac{9}{10}$	55	51	...	37	26	...	42	38	...	23
24	64	54½	...	61	52	$8\frac{9}{10}$	58	50	4	55	49	$4\frac{1}{10}$	38	40	$2\frac{6}{10}$	38	30	...	24
25	65	53	$3\frac{2}{10}$	61	54	...	57	50	...	54	43	...	50	41	$3\frac{2}{10}$	38	31	...	25
26	64	49½	...	63	57	$8\frac{9}{10}$	57	44	...	51	45	...	45	34	$3\frac{5}{10}$	40	30	...	26
27	67	53	...	63	55	...	55	49	...	51	41½	...	40	38	$3\frac{9}{10}$	40	34	...	27
28	65	53	$3\frac{4}{10}$	67	53	...	59	53	$4\frac{7}{10}$	49	38	...	46	48	$4\frac{1}{10}$	36	29	...	28
29	66	56	...	66	51	$9\frac{2}{10}$	57	53	...	49	46	...	58	42	$4\frac{5}{10}$	42	31	...	29
30	65	54	$3\frac{8}{10}$	61	53	...	61	53½	$4\frac{8}{10}$	52	43	...	45	39	$5\frac{1}{10}$	42	37	...	30
31	65	54	4	61	55	$9\frac{3}{10}$	...	...	...	50	35	$4\frac{3}{10}$	...	...	...	42	32	...	31

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On the Distribution of Marine Algæ on the C. L. T. Buoys in the Clyde. By JOHN GRIEVE, M.A., M.D.; and MR. DAVID ROBERTSON, Glasgow.

THE channel of the Clyde from Port-Glasgow to the Cumbraes and the Garrochhead is marked by certain buoys under charge of the Cumbrae Light Trust, and of course laid down in the Admiralty charts. Once a-year, at midsummer, a tug steamer is sent down to lift and remove them. The buoy, which in the course of a year has become covered with algæ and mussels, is disengaged, hoisted on board, and a clean one lowered and fastened in its place. Its compass bearings are then taken, and adjusted if necessary.

One of these buoys, called the Tan buoy, is situated off the S.W. point of the Great Cumbrae, about one and a-half miles from Millport. Upon it the *Polysiphonia Brodiæi* has been found growing in considerable abundance, and in great luxuriance, for many seasons back. It is a plant rarely met with on the adjacent shores of the island. The buoy, however, seems to be a station in some way suited to its habit; and though the new one will be found quite clean two months after it has been laid down, vegetation soon begins to grow over it; the little spores, having found their way through the sea, lodge on the rough surface of the paint; and if examined in early spring, it will be covered with algæ, among which we have strong expectations of finding this same *Polysiphonia.*

The botany of the buoys is somewhat similar to that of the rock-pools near low-water. The algæ are not exposed to tidal influence, as they rise and fall with the buoy, and of course are never subject to those changes which seem to be necessary for the healthy growth of many species. They agree most closely with those which are never left bare, nor are yet far removed from the surface; next with those at low-water-mark; and least of all, with those near high-water-mark which undergo only a short period of submersion.

Having frequently examined the Tan buoy in our dredging excursions, we became desirous of ascertaining whether the *Polysiphonia Brodiæi* was growing on the buoys on the opposite side of the frith, and also how far up the river the algæ of this buoy could be obtained. It is always interesting to compare the plants or animals which are found in stations similarly situated, but in different localities, whether this be done on a large or a small scale, in reference to their general or merely their local distribution. In the Frith of Clyde the buoys present so many stations similarly constituted in every respect, but differing in

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the locality of their situation, each, as we ascend the river, becoming more and more exposed to the influence of fresh or brackish water.

As the easiest way of accomplishing this investigation, we obtained permission to accompany the tug steamer in her annual excursion. Not to lose any opportunity, however, we rowed over from Millport to the Hunterston buoy on the 14th of June last, and again to the Fairley buoy on the 17th, examining the algæ in both cases as far down as could be reached. On the morning of the 18th, at 2.45, we got on board the tug steamer "Glasgow," which had come in for us on the previous evening. At 3 we started, and were soon alongside the Tan buoy. After lifting it, and putting down a clean one in its place, we proceeded to the buoys off Kerritonlia Point and Bogany Point in Bute, Toward Point, Strone Point, and to the Shoals buoy below the Tail of the Bank, thence to No. 3 buoy, opposite the timber ponds, a little below Port-Glasgow, returning to Greenock about 3.45 p.m.

We thus examined nine of these buoys, and obtained on them nineteen genera and thirty-nine species of algæ. No doubt many of the more minute plants escaped our notice, as during the removal of the buoys we had little more than time to pick off what was at once conspicuous to the eye.

The following Table exhibits the distribution of these algæ on the different buoys, with the number of species on each buoy, and the number of buoys on which each species was obtained:—

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TABLE I.

LIST OF ALGÆ Growing on the Buoys at . . .	Hunterston.	Fairley.	Tan, Cumbrae.	Kerritonlia, Bute.	Toward.	Bogany, Bute.	Strone.	Shoals Buoy.	No. 3, Port-Glasgow.	TOTAL.
Desmarestia aculeata,		—	—	—		—				4
viridis,	—	—	—		—	—				5
Laminaria digitata,							—			1
bulbosa,			—							1
saccharina,	—	—	—	—	—	—	—	—		8
Chorda filum,							—		—	2
lomentaria,	—	—	—	—	—		—			6
Cutleria multifida,						—				1
Punctaria plantaginea,	—	—	—	—	—					5
tenuissima,	—									1
Chordaria flagelliformis,	—	—	—	—	—	—	—	—		8
Ectocarpus siliculosus,	—	—		—						3
fasciculatus,					—					1
granulosus, var. tessellatus,		—	—	—	—	—	—	?		6
Hincksiæ,								—		1
pusillus,	—									1
littoralis,	—					—				2
Rhodomela subfusca,						—				1
Polysiphonia urceolata,	—		—	—	—	—		—		6
elongata,			—	—	—	—				4
violacea,				—						1
Brodiæi,		—	—	—						3
nigrescens,				—						1
atro-rubescens,			—			—		—	—	4
Chrysymenia clavellosa,			—					—		2
Delesseria sanguinea,			—			—				2
sinuosa,			—		—					2
Rhodymenia palmata,					—		—	—		3
Ceramium rubrum,	—	—	—	—			—	—	—	7
Callithamnion Daviesii,			—		—					2
virgatulum,	—		—							2
Cladophora lanosa,	—									1
Conferva Youngana,	—							—	—	3
Porphyra laciniata,	—			—				—	—	4
Enteromorpha compressa,	—	—	—	—	—		—		—	7
erecta,		—		—						2
ramulosa,				—						1
Ulva latissima,					—	—	—	—	—	5
Linza,	—	—	—				—	—		5
Total Species,	17	13	20	17	14	13	11	12	7	

The most interesting plant obtained on the Hunterston buoy was the *Ectocarpus pusillus*, which, so far as we know, is new to Scotland, having hitherto been found on the south coast of England.

Only on the Fairley, Tan, and Kerritonlia buoys did we find the

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Polysiphonia Brodiæi. It was very abundant on the two first, but only one bunch was found on Kerritonlia, its place there being taken up by *Polysiphonia elongata*, which was much less abundant on the Tan, and altogether absent on Fairley. Some of the specimens of *P. Brodiæi* on the Tan measured nearly two feet, which is almost double the length of the plant stated in Harvey's *Phycologia Britannica.*

Another notable buoy plant is a form of *Ectocarpus granulosus*, the variety *tessellatus* of Haydn. It grows chiefly on the extremity of the frond of *Laminaria saccharina*, sometimes in tufts over it, and occasionally on the buoy itself. So far as we know, it is not very common on the neighbouring shores of the buoys, and yet was found in fruit upon six of them. A plant very like it was found on the Shoals buoy, but not being in fruit we have not inserted it in our list. A form of *Enteromorpha erecta*, with extremely thick stems and branches, closely covered with capillary ramuli, was obtained on the Fairley and Kerritonlia buoys.

The most remarkable plant on the Bogany Point buoy was the *Cutleria multifida.* It grows in different parts of England and Ireland, and was noticed for the first time in the Clyde a few years ago. *Ectocarpus fasciculatus* was only found on the Toward Point buoy.

The buoys we have mentioned are covered with the common mussel (*Mytilus edulis*). These are all attached to the buoy and chain, and to each other by their *byssus*, forming a great web-like mass, which is readily torn off in sheets. From the under surface of the Bogany buoy they hung down in rope-like clusters, about eighteen inches in length and five in diameter at the base, thence tapering to a point, the mussels also becoming smaller in size towards the free extremity. Pieces of branches are frequently found in the water covered with mussels, but these rope-like clusters had no central support—the mussels were all mutually dependent on each other. While still very abundant on the Strone buoy, they were less so on the "Shoals," on which the barnacles (*Balanus balanoides*) first began to appear. They had almost entirely disappeared from No. 3, Port-Glasgow buoy, the greater part of which was covered with barnacles; and this is the case with all the buoys above Greenock, the barnacles taking the place of the mussels, which is somewhat singular, from the great abundance of the latter in that locality. The piles of the wooden piers in the frith—Wemyss Bay, for example—are covered with mussels up to a certain limit, above which the barnacles alone cover them for three feet, nearly to high-water-mark; but on all the buoys below the Cloch light mussels alone were found.

On the Strone Point buoy the colour of the red algæ showed a

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tendency to become intensified. This was well seen in *Rhodymenia palmata,* and still better in *Chrysymenia clavellosa* on the Shoals buoy. *Ectocarpus Hincksiæ* was only detected on the latter buoy, a large portion of the under surface of which was covered by an extensive colony of *Laomedea dichotoma* ?, but from its exceedingly foul state it was almost impossible to make out the species.

On Port-Glasgow buoy, No. 3, we obtained seven species, each belonging to a different genus. Notwithstanding the large admixture of fresh water at this station, the *Polysiphonia atro-rubescens,* which was also got on the Tan buoy, and is a common plant on the shores of the frith, was above the average size, of a fine dark purple colour, and abundantly in fruit, showing that it was still in a healthy condition.

Not to enter further into details, we would merely state that the plant comparatively most luxuriant was the *Polysiphonia Brodiæi;* the most stunted, on the other hand, were *Delesseria sanguinea* and *D. sinuosa.* In the following Table is shown the distribution of the algæ according to the number of buoys on which they were growing.

TABLE II.—LIST OF ALGÆ GROWING

Upon Eight Buoys.
Laminaria saccharina.
Chordaria flagelliformis.

Upon Seven Buoys.
Ceramium rubrum.
Enteromorpha compressa.

Upon Six Buoys.
Chorda lomentaria.
Ectocarpus tessellatus.
Polysiphonia urceolata.

Upon Five Buoys.
Desmarestia viridis.
Punctaria plantaginea.
Ulva latissima.
Ulva Linza.

Upon Four Buoys.
Desmarestia aculeata.
Polysiphonia elongata.
    atro-rubescens.
Porphyra laciniata.

Upon Three Buoys.
Ectocarpus siliculosus.
Polysiphonia Brodiæi.
Rhodymenia palmata.
Conferva Youngana.

Upon Two Buoys.
Chorda filum.
Ectocarpus littoralis.
Chrysymenia clavellosa.
Delesseria sanguinea.
    sinuosa.
Callithamnion Daviesii.
    virgatulum.
Enteromorpha erecta.

Upon One Buoy.
Laminaria digitata.
    bulbosa.
Cutleria multifida.
Punctaria tenuissima.
Ectocarpus fasciculatus.
    Hincksiæ.
    pusillus.
Rhodomela subfusca.
Polysiphonia violacea.
    nigrescens.
Cladophora lanosa.
Enteromorpha ramulosa.

Though it may be rash to draw any conclusion from a single day's excursion, it will be seen from Table I. that there is in general a

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diminution in the number of species as we ascend the river. The Toward and Bogany buoys, at the entrance into Rothesay Bay, show a less number than those farther down, with the exception of Fairley, where the difference may perhaps arise from its situation. Still fewer grow on the Strone Point and Shoals buoys; while the small list on No. 3 is eminently characteristic of the upper part of the river.

These buoys are all made of iron, with the exception of the one at Toward Point, which is either altogether of wood, or of iron covered with latticed wood-work; but neither did this, nor the colour of the paint, appear to have any influence on the algæ. There was no appreciable difference between those growing on the red buoys of the one side and the black ones on the other side of the frith. Although the buoys are removed every year, and replaced by others newly painted, the same plants in general are found on them next season, and nearly in a similar proportion. Some of these, as already stated, are rarely found on the adjacent shores. In this case the spores carried to the new buoy must find something suitable for their growth in that situation. That the spores do not find their way from the few plants left on the deep and unscraped portion of the chain (and very few plants were seen on the chain near the buoy), is evident from the fact that the *Laminaria saccharina* must have been growing for a considerable time before the spores of such species as *Ectocarpus tessellatus* took root on its fronds.

On the Use of Mechanical Hypotheses in Science, and especially in the Theory of Heat. By Professor Rankine.

The object of the present paper is to illustrate the use of mechanical hypotheses in physical science, by giving a short account of the results which have been derived from that hypothesis which ascribes the mechanical action of heat to the centrifugal force of certain supposed molecular motions. That hypothesis, like the wave theory of light, the hypothesis of atoms in chemistry, and all other physical hypotheses whatsoever, substitutes a supposed for a real phenomenon, viz., invisible motion for tangible heat; the object being to deduce the laws of the real phenomenon from those of the supposed one. If the supposed phenomenon were more complex, or less completely known in its laws than the real one, the hypothesis would be an incumbrance, and worse than useless. But such is not the case with the hypothesis of molecular motions as applied to heat. The laws of motion are at once simpler and more thoroughly known than those of any other phenomenon; and as the hypothesis in question enables the known laws of the mechanical action of heat to be deduced from the laws of motion, it tends towards

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the simplification of science, just as the hypothesis of undulations does by enabling all the phenomena of reflection, refraction, diffraction, interference, polarization, and dispersion, whether of light or of radiant heat, to be deduced from the same laws of motion.

A hypothesis is absolutely disproved by any facts that are inconsistent with it. For example, the corpuscular or projectile hypothesis regarding light is absolutely disproved by the fact of the less velocity of light in the more highly refracting media, which is contradictory of one of its necessary consequences; the hypothesis of the substantial existence of "caloric," or the "subtle fluid" of heat, is absolutely disproved by the fact, established by the experiments of Rumford, Davy, Mayer, and Joule, of the production of an unlimited quantity of heat from a limited quantity of matter by means of friction; by that of the constancy of the specific heat of air at all densities, established in 1853 by M. Regnault; and by that of the almost total disappearance of the cooling effect of the expansion of gases, when they expand without performing work, established about 1851-2, by Messrs. Joule and Thomson. On the other hand, no hypothesis is capable of absolute proof by any amount of agreement between its results and those of observation; such agreement can give at best only a high degree of probability to the hypothesis.

In order to establish that degree of probability which warrants the reception of a hypothesis into science, it is not sufficient that there should be a mere loose and general agreement between its results and those of experiment. Any ingenious and imaginative person can frame such hypotheses by the dozen. The agreement should be mathematically exact, to that degree of precision which the uncertainty of experimental data renders possible, and should be tested in particular cases by numerical calculation. The highest degree of probability is attained when a hypothesis leads to the prediction of laws, phenomena, and numerical results which are afterwards verified by experiment; as when the wave theory of light led to the prediction of the true velocity of light in refracting media, of the circular polarization of light by reflection, and of the previously unknown phenomena of conical and cylindrical refraction; and as when the hypothesis of atoms in chemistry led to the prediction of the exact proportions of the constituents of innumerable compounds.

It is unnecessary to enter into any lengthened explanation as to the hypothesis of the radiation of heat consisting in the transmission of a vibratory or oscillatory movement; for that hypothesis forms in fact one theory with the corresponding hypothesis regarding light, the principles of both being identical, and the facts to which they are applied analogous in every respect.

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The accordance of the results of that hypothesis with the phenomena of radiant heat, together with the fact of the production of heat by the friction of solids and fluids, naturally suggest the probability that some similar hypothesis may be found to agree with the phenomena of the mechanical action of heat. And in the first place it may be remarked, that the loose and general agreement with the observed laws of the phenomena, which has already been mentioned as not being of itself sufficient to warrant the reception of a hypothesis, is possessed by every supposition which ascribes heat to the minute motions of the particles of bodies, of what kind soever the motions may be supposed to be; for every kind of internal motion would make the particles tend to fly asunder and occupy more space, and hence expansion by heat, and the evaporation of solids and liquids, which is an extreme case of expansion; it would make them press outwards against the boundaries of any space in which they were confined, and hence the increase of elastic pressure by heat; it would be communicated from particle to particle, and hence the transmission of heat; it would tend to dislodge the particles from any regular arrangement, and hence the softening and melting of solids, and the occasional decomposition of chemical compounds by heat. It would be increased in rapidity by the expenditure of mechanical power in the body, whether through friction, percussion, compression, or the exertion of electric, or chemical, or other molecular forces amongst the particles, and hence the production of heat by those means; the heat produced would also bear a constant ratio to the mechanical power exerted; the molecular motion would be weakened by the enlargement of the space occupied by the particles and by their removal to greater distances apart, against external pressure and their mutual attraction, and hence the disappearance of heat in expansion, evaporation, and chemical decomposition; and in this case the heat which would disappear would bear the same constant ratio to the work performed against the forces resisting the expansion.

As an example of a hypothesis presenting this general agreement with the phenomena, there may be cited that proposed by Mr. Herapath and Mr. Waterston, which may be called the "Hypothesis of Molecular Collisions," and which supposes particles to fly about in all possible directions with velocities the mean of whose squares is proportional to the quantity of heat in a given weight of the substance. It is defective, however, in the agreement of its numerical results with those of experiment, inasmuch as it gives a fixed value, 5 : 3, or $1\frac{2}{3}$, for the ratio of the specific heat of a gas under constant pressure to its specific heat at constant volume; whereas that ratio is certainly known to be 1·408 for those gases in which it is greatest, and much smaller in others. Other defects of the same kind were pointed out by Professor

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Clerk Maxwell, in a paper read to the British Association at Aberdeen in 1859.

The hypothesis to which I have to call your attention as presenting the requisite precision of agreement with the results of experiment, and as having also predicted some of those results, is that which may be called the "Hypothesis of Molecular Vortices," or the "Centrifugal Theory of Elasticity," in which the elastic pressure produced by heat is ascribed to the centrifugal force of invisibly small whirls or eddies amongst the particles of bodies; the energy, or living force, of such whirls being the *quantity* of heat. The first idea of a supposition somewhat resembling this appears to have been put forth by Sir Humphry Davy;* but so far as I know, no reduction of it to a definite form, nor investigation of its consequences on strict mathematical and mechanical principles, was published before the appearance of a paper which was communicated by me to the Royal Society of Edinburgh, in December, 1849, and which was read in February, 1850, and printed in the 20th volume of the *Transactions* of that body. The nature of the hypothesis, as set forth in that paper, will be best explained by the following extracts from the printed abstract of the paper:—

"The hypothesis of molecular vortices is defined to be that which assumes, *that each atom of matter consists of a nucleus or central point, enveloped by an elastic atmosphere, which is retained in its position by attractive forces, and that the elasticity due to heat arises from the centrifugal force of those atmospheres, revolving or oscillating about their nuclei or central points.* According to this hypothesis, *quantity of heat is the* vis viva *of the molecular revolutions or oscillations.*

. . . .

"The author introduces into the hypothesis of molecular vortices a supposition peculiar to his own researches, for the purpose of connecting it with the undulatory hypothesis as to radiation. It is this: *That the vibration which, according to the undulatory hypothesis, constitutes radiant light and heat, is a motion of the atomic nuclei or centres, and is propagated by means of their mutual attractions and repulsions.* The absorption of light and of radiant heat, according to this supposition, is the transference of motion from the nuclei or centres to their atmospheres, and the emission of light and radiant heat, the transference of motion from the atmospheres to the nuclei or centres. The author enumerates several advantages which he conceives that this hypothesis possesses over the common supposition of a luminiferous ether pervading the spaces between ponderable particles."

. . . .

* *Chemical Philosophy*, Part I., Division I., Section 5, Article 14.

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In the paper just referred to the application of the hypothesis was confined to gases and vapours; but in a series of subsequent papers it was extended to substances in all conditions.*

Amongst the consequences deduced by the application of the known principles of mechanics were *the two laws of thermodynamics*, by which, as is now well established by experiment, the results of all mechanical actions of heat can be computed with a precision limited only by the precision of the data.

The *first law* is the fact established experimentally by Mayer and Joule, about 1842-3, *that a given quantity of heat requires for its production, and produces by its disappearance, mechanical energy bearing a constant ratio to the quantity of heat.* This law forms, of course, an essential part of any theory which regards heat as a form of motion. The numerical relation between heat and mechanical energy could be determined by experiment alone. Mr. Joule's experiments, after eight years of perseverance, during which the precision of his methods of experimenting was continually increased, gave at last 772 foot-pounds of mechanical energy as the equivalent of a British Unit of Heat (*Philosophical Transactions,* 1850)—a result whose exactness has been confirmed by every subsequent experiment.

The *second law* of thermodynamics was arrived at independently and published simultaneously by Professor Clausius of Zürich and myself. It was arrived at by Professor Clausius through the application to the first law, as demonstrated by Mayer and Joule, of a peculiar process of reasoning, analogous to that which Carnot, in 1824, had applied to the hypothesis of fluid caloric, in his *Réflexions sur la Puissance Motrice du Feu.* It was deduced in my investigation from the mechanical hypothesis already stated, by means of the general principles of dynamics. Its *experimental* demonstration was not effected until about 1852, through the labours of Mr. Joule and Professor William Thomson. There are various different forms of stating the second law. The following is, perhaps, the most easily intelligible:—*The mechanical equivalent of the quantity of heat which disappears during a given expansion, or appears during a given compression, of any substance at a given constant temperature, is the product of the following three factors:—*

The change of volume of the substance.

The rate of variation of its elastic pressure with temperature when the volume is constant.

The absolute temperature, measured from a point 493°·2 of Fahrenheit below the melting point of ice.†

* *Trans. of the Royal Society of Edinburgh*, vols. xx., xxi.; also *Philos. Magazine*, 1851.

† By suitable modifications, this law can be made applicable to alterations of figure, as well as to alterations of volume.

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Amongst the predictions made by the aid of those two laws were the following:—Up to 1850 the received value of the specific heat of air, under a constant pressure of one atmosphere, was ·2669; and in accordance with the hypothesis of fluid caloric, it was generally believed that a diminution of pressure produced an increase of specific heat, and *vice versâ*. In 1850 I ventured to predict that the true specific heat of air, under constant pressure, would be found to be 0·24, or thereabouts, and very nearly constant at all pressures. It was not until 1853 that M. Regnault's experiments appeared, proving the truth of both these assertions. It was by means of the second law of thermodynamics that tables of the densities of saturated steam, at temperatures ranging from 32° to 428°, were computed, from the known values of the latent heat of evaporation, in 1853 and 1854, five years before the experimental determination of those densities by Messrs. Fairbairn and Tate; and similar calculations were applied with equal success to some other vapours. (*Phil. Trans.*, 1854; *Phil. Mag.*, Dec. 1854.)

The preceding results are consequences of the two laws of thermodynamics, whether we regard those laws as demonstrated independently by experiment, or as consequences of a mechanical hypothesis. But the following are consequences peculiar to the hypothesis of molecular vortices, and not, so far as I know, deducible from any other supposition which has yet been put forth as to the constitution of matter.

According to that hypothesis the elastic pressure of a gas or vapour consists of the centrifugal force of its whirling particles, partially counteracted by their mutual attraction. The pressure due to centrifugal force is the product of the density, the absolute temperature, and a constant quantity depending on the nature of the substance; and such is the law of the pressure of a *perfect gas*, or one in which the effect of molecular attraction in partially counteracting the centrifugal force is insensible; while the diminution of such pressure, produced by molecular attraction, is expressed by a series of terms increasing more rapidly than the simple power of the density, and proportional to the powers of the *reciprocal of the absolute temperature.* This last force, which may be called the *cohesion* of gases, is what distinguishes an imperfect gas from a perfect gas. It is very considerable in saturated vapours; less, though still appreciable, in the denser gases, such as carbonic acid; and very small in air. The cohesion of carbonic acid gas was found to be represented by the *square of the density, divided by the absolute temperature,* and multiplied by a co-efficient deduced from the experiments of M. Regnault on the rate of expansion of that gas. Experiments were afterwards made by Messrs. Joule and Thomson on the disappearance

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of heat in overcoming this cohesion, and the results closely agreed with those deduced from the above-mentioned expression.

The hypothesis of molecular vortices, when applied to the question of the relation between the pressure of saturated vapour and the boiling-point of its liquid did not give a precise result, for want of experimental data; but showed it to be *probable* that an approximate formula for the *logarithm of the pressure* of any vapour would consist of a constant diminished by a series of terms proportional to the powers of the reciprocal of the absolute temperature. This conclusion was found to be completely verified by the vapours of water, alcohol, ether, sulphuret of carbon, mercury, and other fluids. (See *Edinburgh New Philosophical Journal*, July 1849, and the *Philosophical Magazine* for 1854.)

I think I am justified in claiming for the hypothesis of molecular vortices, as a means of advancing the theory of the mechanical action of heat, the merit of having fulfilled the proper purposes of a mechanical hypothesis in physical science, which are, to connect the laws of molecular phenomena by analogy with the laws of motion, and to suggest principles, such as the second law of thermodynamics, and the laws of the elasticity of imperfect gases, whose conformity to fact may be afterwards tested by direct experiment; and I make that claim the more confidently that I conceive the hypothesis in question to be in a great measure the development, and the reduction to a precise form, of ideas concerning the molecular condition which constitutes heat, that have been entertained from a remote period by the leading minds in physical science, and amongst others, by Galileo, Bacon, Boyle, Newton, Montgolfier, Seguin, Rumford, Davy, Leslie, and Young. As an example of the views held at the present time respecting it by eminent men of science, I may refer to Dr. Lloyd's opening address as President of the British Association, at the Dublin meeting, in 1857, page 59. I may also refer to the fact that Professor Clerk Maxwell is now publishing, in the *Philosophical Magazine,* a series of papers, in which he shows how the laws of electricity may be deduced from the hypothesis of molecular vortices.

I wish it, however, to be clearly understood, that although I attach great value and importance to sound mechanical hypotheses, as means of advancing physical science, I firmly hold that they never can attain the certainty of observed facts; and accordingly I have laboured assiduously to show that the two laws of thermodynamics are demonstrable as facts, independently of any hypothesis: and in treating of the practical application of those laws, I have avoided all reference to hypothesis whatsoever.

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January 29, 1862.—*The* President *in the Chair.*

The following gentlemen were elected members of the Society, viz.: —Mr. Henry S. Macpherson, 21 West Prince's Street; Mr. David Ritchie, Iron-founder, Pollokshields; Mr. James Carrick, Hotel Proprietor, 50 George Square; Mr. Alexander Macdonald, 12 Claremont Terrace; Mr. John Stott, Actuary, 39 St. Vincent Place.

Dr. Anderson made some observations on Paranapthaline.

Professor H. D. Rogers continued his "Inquiry into the Physical Causes and some of the Social Effects of the Abnormal Distribution of Temperature in North America," and expressed his wish to resume the subject on a future occasion.

February 12, 1862.—*The* President *in the Chair.*

Mr. John William Baxter, Merchant, 3 Virginia Street, was elected a member of the Society.

The President reported that to-day a meeting of representatives of the Scientific Societies of Glasgow was held in the Hall of this Society, on the invitation of the Council, when it was unanimously agreed to present a joint Address of Condolence to the Queen on the death of Prince Albert. The Societies represented at the meeting were the Philosophical Society, the Institution of Engineers in Scotland, the Architectural Society, the Archæological Society, the Shipbuilders' Association, the Natural History Society, the Geological Society, and the Association of Assistant Engineers. Professor Rankine and Mr. Keddie were appointed a committee to prepare the draft of an address.

Dr. Allen Thomson described the "Mechanism of Respiration in the Lower Animals, and principally in Birds."

On Co-operative Societies in Glasgow. By Mr. John D. Campbell, Sub-Inspector of Factories.

I do not intend in this paper to give a full account of the Co-operative Societies at present existing in Glasgow, which would require a more laborious inquiry than I have had patience to make, and would be, after all, of little importance, as co-operative societies are extending themselves so rapidly that statistics, however carefully collected, would soon be antiquated. I merely wish to lay before the Philosophical Society a sketch of the present position of the co-operative movement, that those members who take an interest in such subjects may be enabled to inquire for themselves into its prospects and its value as a means for the elevation of our labouring classes.

Co-operative societies of various kinds have long existed in Glasgow, but the great impulse which they have recently received has been due

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to their success in the North of England, especially at Rochdale and Leeds. The history of the Rochdale societies must be pretty well known to most persons here present, but it is probably new to some, and I shall therefore give a very brief account of it, which will serve as an introduction to my sketch of the Glasgow societies, most of which are established on the Rochdale system.

In the year 1844 twenty-eight persons established the society called the Rochdale Equitable Pioneers. They were, I believe, mostly Owenite Socialists, and I mention this fact because, though I think that many of Robert Owen's principles are erroneous, and some of them detestable, it shows that he had the power of impressing his disciples with that faith which has in all ages and countries been the mother of great deeds. These twenty-eight persons subscribed a capital of £28, with which they started a grocer's shop on a very small scale. The principles on which the society was started were in many respects original. The shares are not transferable, but any shareholder may, subject to certain restrictions, demand the re-payment of his capital. All shareholders have an equal vote in the management of the concern, and receive a uniform dividend of five per cent. on the capital invested—the remaining profits being divided among purchasers of goods in proportion to the amount of their purchases, tin tickets being given to every customer when he makes a purchase, which are collected quarterly, and show the amount of each customer's dealings. The society has now several branches, and sells groceries, butcher meat, draperies, shoes, and clogs, which are largely worn in the North of England. Its success may be seen from the following statistics, which I take from the Rochdale Equitable Pioneers' *Almanack* for 1862:—

Year.	Capital.	Sales.	Profit.
1844	£28	—	—
1845	182	£710	£33
1846	252	1,147	81
1847	287	1,925	72
1848	397	2,276	118
1849	1,194	6,612	561
1850	2,300	13,180	890
1851	2,785	17,638	991
1852	3,471	16,352	1,207
1853	5,848	22,760	1,675
1854	7,173	33,364	1,764
1855	11,033	44,903	3,106
1856	12,921	63,198	3,922
1857	15,142	79,788	5,470
1858	18,160	71,689	6,285
1859	27,061	104,012	10,740
1860	37,710	152,063	15,906
1861	42,926	176,207	18,020

The dividend on purchases for the last quarter was at the rate of 2s. 1d. in the pound.*

* This large dividend is partly derived from investments in other co-operative societies, and no dividend is given on purchases of sugar, which swells the apparent profit on other articles. The Glasgow societies pay a dividend on sugar.

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In the year 1851 a corn mill was established, which supplies flour to many co-operative societies in the neighbourhood of Rochdale, and to the public at large, but whose best customer has always been the Pioneers' Society, who have had a considerable sum invested in it from its commencement. This concern has also been very successful. I will not trouble the meeting with its statistics year by year, but in 1861 they stood thus—

Capital,......£29,600 ...... Business,......£166,800 ...... Profits,......£10,000.

There is also the Rochdale Manufacturing Society, the Co-operative Land and Building Society, and others, which I will not detain the meeting by describing.

I now proceed to give an account of some of the Glasgow co-operative societies, especially of those which are established on Rochdale principles. The most important of these is the Glasgow Co-operative Society, which started in February, 1858, just four years ago, on a very moderate scale, their total capital, after payment of preliminary expenses, being £5. Since this unpromising beginning, its progress has been as follows:—

	Members.	Capital.	Goods Sold.	Profit.
First year,............	57	£45	£221	£9.
Second year,.........	404	175	1,151	52.

In the course of the following year a great impetus was given to the cause of co-operation in Glasgow by the meeting of the Social Science Association, and by the delivery and circulation of a lecture by Mr. Wm. Chambers, strongly advocating co-operative principles. The result of this was, that at the end of the third year the account stood thus—

Members, 1,143 ... Capital, £1,070 ... Goods Sold, £8,168 ... Profit, £375.

The accounts for the fourth year have not yet been made up, but the report for the quarter ending Dec., 1861, shows, that the capital had increased to £1,975, and the goods sold, to £7,745, *i. e.*, about £31,000 a-year. The profits for the quarter were £442, and the dividend on purchases 1s. 1d. in the pound. It might naturally be supposed that the income of the Society would have suffered from the depressed state of trade which now unhappily prevails, but this has not been the case, for I am informed that the sales for the last two weeks have exceeded £700 per week, *i. e.*, £37,000 per annum, and this increase has been marked in the Calton, where most of the members are dependent on the cotton trade.

The Society has now a central establishment at 11 Stirling Street, City, and branches in Calton, Bridgeton, Cowcaddens, Anderston,

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Laurieston, Parkhead, Maryhill, and Pollockshaws, at all of which groceries are sold, drapery goods and boots and shoes being also sold at the central store, but not at any of the branches. There is also a bakehouse in the Gallowgate, containing three ovens, which is now too small for their increasing business, and the Society is making arrangements for the purchase of a piece of land on which to erect a bakehouse of their own, containing ten ovens, together with stables and other buildings for the use of the Society. The additional capital required for this purpose is being rapidly subscribed, and the only delay is caused by the difficulty of procuring a suitable piece of ground. Some members talk of starting a corn-mill as their next enterprise, but the more cautious think that they had better wait a little longer before undertaking a work of such magnitude.

There are several other societies on the same principle in Glasgow which I need not refer to at much length, such as the West of Scotland (formerly the Blacksmiths') Co-operative Society, with three branches, and a business of £6,500 per annum; the St. Rollox Co-operative Society, originally started by the workmen of Tennant's chemical works, with two shops, and a business of about £6,000 a-year; the Caledonian Co-operative Society, chiefly supported by servants of the Caledonian Railway, with a shop in Cumberland Street, and a business of £3,900 a-year; the Artizans' Co-operative Society in Sydney Street, with a business of £2,500 a-year; the Southern Co-operative Society in Hospital Street, whose members come mostly from Dixon's iron-works, and probably some others. There are also many societies more or less resembling these, some of which, as the Kelvinhaugh Society, divide all profits among shareholders; and some, such as the Bridgeton Old Society, among purchasers; and have other differences in their constitutions which I have not particularly inquired into. Among these I may mention two in Bridgeton (one of which has been established thirty years) one at Tollcross, one at Parkhead, one at Kelvinhaugh, and two or three at Rutherglen. As my object has been to direct the attention of those present, especially of employers of labour and others who are thrown much in contact with the working classes, to the increase of co-operative societies, rather than to give a detailed account of them, I have not obtained complete statistics of their operations; but I am convinced that the aggregate amount of their dealings would be considerably under-estimated at £70,000 per annum, and this amount is steadily and rapidly increasing. The co-operative principle is also being applied in the towns and villages in the neighbourhood. I know that stores on the Rochdale model are in successful operation at Paisley (where a business of £400 a-week is done), Greenock, Port-Glasgow, Thornliebank,

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Alexandria, Dumbarton, and Busby, and no doubt in many other places. Attempts are now making to unite the different Glasgow societies into one body, and conferences of delegates are being held to discuss the subject; but I do not know whether any progress has as yet been made in these negotiations.

Let us now consider the effect of these societies on the condition of the working classes, by whom they are almost exclusively supported. In the *first* place, all sales are made for ready money. This is of itself an immense advantage, as all must see who are acquainted with the injurious effects of the credit system, which are even worse in Scotland than in England, owing to the operation of the law of arrestment.

Secondly. The articles sold in these shops are sure to be of good quality; if they were not, the shareholders would soon remonstrate.

Thirdly. Though the goods are sold at the same price as in other shops, they are a good deal cheaper in the end, as a considerable portion of the price is returned in the shape of dividend to purchasers.

Fourthly. By far the most important advantage of these societies is the encouragement they give to provident habits among the labouring classes. All who are acquainted with the habits of our workmen must know how frequently even the well paid and well conducted among them live entirely from hand to mouth, and are reduced to utter destitution by a short period of sickness or loss of employment. Much good has no doubt been done by Savings Banks; but these have never become thoroughly popular with the working classes, who look with a certain amount of suspicion on all institutions not originating among and managed by themselves.* These societies form a ready means for the investment of the savings of the working classes, and all accruing interest is added to the principal, as in a Savings Bank, though it may be drawn out at the end of the quarter, if the shareholder wishes to do so. Besides this, every purchase made is actually accompanied by a deposit in the Savings Bank, without trouble to the purchaser; for the proportion of profit divisible on purchases is carried to the account of the purchaser, in the same manner as the dividend on capital.

I may, perhaps, seem to some to have been too zealous in my advocacy of the co-operative principle; but I am fully alive to its difficulties and dangers. The Equitable Pioneers' Society at Rochdale, and most of the other successful co-operative societies, were started in the face of great difficulties, and the experience gained by their promoters in the up-hill work of the commencement was of great service to them in more prosperous times. It is now a very easy thing to start a co-opera-

* The failure of the Rochdale Savings Bank was one great cause of the rapid progress of co-operation in Rochdale.

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tive society, and there is much more danger that the management may be entrusted to incompetent persons. Besides, there is always a chance, especially when a society has several branches, that losses may be incurred through fraud on the part of some of the salesmen. A prosperous society in Manchester was involved not long ago in considerable difficulties from this cause; but as soon as the deficiency was discovered, the directors had the courage to look their difficulties in the face, and have now entirely overcome them. There is also a very natural wish to make things pleasant by a large dividend, against which the managers should be on their guard. An error in the quarterly stocktaking, or an insufficient allowance for depreciation of plant, may at any time give a delusive appearance of prosperity; but I believe that most men engaged in the management of these societies are careful to avoid such errors, knowing that they must be paid for in the end.

But the grand sheet-anchor of the co-operative societies is the ready-money system, which is in most cases rigidly adhered to, and which, by simplifying accounts and preventing bad debts, renders the management far more simple and less hazardous.

In conclusion, I would call on all employers of labour, and others who take an interest in the welfare of the working classes, to examine the working of these societies for themselves, and draw their own conclusions. If, as I believe, they are the best means yet invented for enabling the labourer to maintain his independence, to keep beforehand with the world, and to lay by something for his support in old age, they surely deserve our sympathy, if not our assistance.

Mr. Ramsay of Kildalton made some remarks on a system of co-operation which originated in the neighbourhood of this city about thirty years ago, and inquired whether any of the members were aware of the causes of its failure?

Mr. Harvey mentioned that more than thirty years since a co-operative society was established at St. Rollox, by the work-people, but they fell into the mistake of giving credit, in consequence of which the funds were exhausted, and the store was shut up.

Mr. W. M'Adam inquired whether the co-operative system in Rochdale included the manufacture of goods, and whether the society went into the market with its manufactures?

Mr. Campbell replied that although references to co-operative cotton mills in the north of England might have been frequently observed, there were only two that were really co-operative, giving a share in the profits to the workers employed, the greater number being

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simply joint-stock companies, with small shares, held by a large number of persons, as was the practice in America. There was one such manufacturing company in Rochdale, and one had been recently started in Manchester. They had succeeded so far as to yield good returns when trade was prosperous; but it was doubtful whether they would stand against the pressure of bad times. The Rochdale company had divided five per cent. for the half-year ending December, 1861. In reply to another question, Mr. Campbell said that the co-operative societies made it a rule not to take credit, although in conducting a wholesale trade it was of course difficult to avoid it altogether.

MR. CROSSKEY remarked that the co-operative system enjoyed a legal protection against fraud under the Friendly Societies Act, such as did not exist under the old law. The effect of the system in improving the habits of the working people could not be over-estimated. By giving credit the small shop-keepers got them into debt, and it was their policy to prevent them from getting out of it. By ready-money payments at the co-operative store, the purchasers received better articles, and at the same time became accustomed to habits of economy. The interest in the societies was widely diffused. Nobody could have more than a hundred pounds of capital in the concern. Then the responsibility of the management was shared by the purchasers, who appointed independent committees to check the accounts. Every purchaser, besides, received checks corresponding to the number of his purchases. In short, the whole system was one of self-management and self-discipline, and was unquestionably producing a wholesome effect on the habits of the working classes.

MR. J. JEFFRAY asked Mr. Campbell if he had turned his attention to the working men's co-operative associations in France, which were believed to be prosperous?

MR. CAMPBELL said that these institutions had only casually come under his attention in the course of his reading; but he was led to understand that the system was successful in France.

The PRESIDENT observed that the subject was one of great practical importance. The success of the system afforded proof that working men do not need to be patronized in an undertaking of this nature; all that was necessary to induce them to establish co-operative societies was merely to furnish them with information as to what had been already done. This was almost the only plan for their benefit which had ever proved successful; and it originated with themselves and was managed by themselves. The economical advantages of the system were obvious. By purchasing on credit, the working classes not only got inferior provisions, but paid a higher price for all the necessaries of life than people

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in the middle and upper classes. The co-operative system relieved them from this disadvantage; and, viewed in its effects upon their habits and condition, it was one of the greatest developments of social science. But one of the secrets of its success was, that, in working it out, the people had been left to themselves; and any attempt on the part of others to interfere with them would manifestly do harm.—The President moved the thanks of the Society to Mr. Campbell for bringing the subject under their attention; and thanks were voted accordingly.

February 26, 1862.—*The* PRESIDENT *in the Chair.*

Mr. William Sim, 13 Walmer Crescent, was elected a member of the Society.

Mr. James Napier, Chemist, read "Notes on Partick in Olden Times."

Mr. W. Keddie read a paper "On the Remains of a Vitrified Fort or Site in the Island of Cumbrae, with Notes on the Vitrified Forts of Berigonium, Glen Nevis, Craig Phadrick, and Bute."

The President reported that the following joint address of condolence to the Queen, on the death of Prince Albert, had been approved of by the representatives of the different Societies, and transmitted to Sir George Grey for presentation to her Majesty:—

TO THE QUEEN'S MOST EXCELLENT MAJESTY.

MOST GRACIOUS SOVEREIGN,—We, your Majesty's loyal and dutiful subjects, the Members of the Scientific Societies established in the city of Glasgow, humbly approach your Royal Presence with the expression of our profound sympathy and heartfelt condolence on the irreparable loss which your Majesty and the British empire have sustained in the death of your Royal Consort,—in whose private and public character we had long been accustomed to recognize the habitual manifestation of every princely virtue,—a faithful and affectionate husband, a loving and judicious father, the sagacious counsellor of your Majesty, and the tried and trusted friend of all ranks of the British people.

His Royal Highness came to this country a stranger, but he speedily acquired an intimate knowledge of our national character, and a not less clear perception of our national deficiencies. Impelled by the instincts of his noble nature, and guided by his highly cultivated mind and vig-

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orous understanding, he inaugurated and identified himself with many objects of social progress and national improvement, to which, with exemplary earnestness and persistency, he lent the influence derived from his exalted station, and the practical wisdom acquired by observation and experience. Nor did His Royal Highness confine his interest to the limits of the British Empire. In his comprehensive view, the wisdom of the patriot blended with the benevolence of the philanthropist; and the prosperity and advancement of the British nation were inseparably connected with a generous regard to the amelioration of mankind at large. Appreciating with rare sagacity the tendency of the age in which we live, he evinced a constant desire that the moral influence of his adopted country should prove instrumental in giving a wholesome direction to the social progress of the nations; and we recall with mournful satisfaction the memorable and weighty words on that subject, in which our wise and good Prince, though dead, will continue to speak with impressive authority to the men of this and the coming time:—"Nobody who has paid any attention to the peculiar features of our present era will doubt for a moment that we are living at a period of most wonderful transition, which tends rapidly to accomplish that great end to which, indeed, all history points—*the realization of the unity of mankind.*"

Associated as we are, in our several spheres, for the advancement of abstract and practical Science in a great commercial and manufacturing community, we felt an ever-growing admiration of the efforts, alike skilful and successful, of His Royal Highness to encourage the study of Science, to develop the industrial resources of the nation, to stimulate the inventive ingenuity of its artizans and mechanics, to disseminate a love of the Fine Arts, and promote the spread of common education.

We have heard with thankfulness of the devout resignation with which your Majesty has been enabled to bear this heavy affliction; and we feel assured that, next to the consolation vouchsafed from the Source of all true comfort, is the satisfaction experienced by your Majesty in reflecting upon the unmingled felicity of past years, resulting from the interchange of the domestic affections, the faithful discharge of mutual duties and public responsibilities, and the pains unreservedly bestowed upon the training of the youthful members of the Royal Family; to whom your Majesty's loyal subjects will look with confidence, under the Divine blessing, to reflect the virtues which have so eminently characterized their Royal parents, and perpetuate the glory of a reign the most prosperous and illustrious in the annals of our beloved native land.

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Signed by the President and Secretary of each of the following Societies, viz.:—

PHILOSOPHICAL SOCIETY OF GLASGOW.
INSTITUTION OF ENGINEERS IN SCOTLAND.
ARCHITECTURAL SOCIETY.
ARCHÆOLOGICAL SOCIETY.
SCOTTISH SHIPBUILDERS' ASSOCIATION.
NATURAL HISTORY SOCIETY.
GEOLOGICAL SOCIETY.
ASSOCIATION OF ASSISTANT ENGINEERS.

March 12, 1862.—*The* PRESIDENT *in the Chair.*

Mr. John Robertson, Coalmaster, 173 Great Eastern Road, was elected a member of the Society.

The following letter was received from Sir George Grey, Her Majesty's Secretary of State for Home Affairs:—

WHITEHALL, 10*th March*, 1862.

SIR,—I have had the honour to lay before the Queen the loyal and dutiful Address of the Scientific Societies established in the city of Glasgow, on the occasion of the death of His Royal Highness the Prince Consort; and I have to inform you that Her Majesty was pleased to receive the Address very graciously.—I am, Sir, your obedient Servant,

G. GREY.

THE SECRETARY OF THE
PHILOSOPHICAL SOCIETY, GLASGOW.

Mechanical Theory of the Predominance of the Right Hand over the Left; or, more generally, of the Limbs of the Right Side over those of the Left Side of the Body. By ANDREW BUCHANAN, M.D., Professor of Physiology in the University of Glasgow.

THE use of the right hand in preference to the left must be regarded as a general characteristic of the family of man. There is no nation, race, or tribe of men on the face of the earth, at the present day, among whom this preference does not obtain; while, in former times, it is shown to have existed, both by historical documents and by the still more ancient and authentic testimony of certain words, phrases, and modes of speaking, which are, I believe, to be found in every spoken

language. A custom so universal cannot, I think, be supposed to be a mere human institution, by which I mean a conventional arrangement founded on utility or expediency, and maintained by example and precept. The object of this memoir is to show, on the contrary, that the custom is adopted in obedience to physiological laws, and that it depends on causes lying deep in the human organization.

I. PHENOMENA TO BE EXPLAINED.—Let us first endeavour to ascertain the facts to be explained, without any thought of the explanation; and, with that view, let us compare the two sides of the body, and more especially the limbs in reference to their structure and the uses we make of them.

When we look at the right arm of a full-grown man, and compare it with the left, we at once see that the former has the advantage over the latter in point of size. We discover, also, without difficulty, a corresponding inequality in the lower limbs, and we may say generally in the two sides of the body, considering the number of tissues that are common to the limbs and trunk. On more minute examination we find the inequality to be chiefly due to the greater development of the muscles of the right side, which are brawnier, and have stronger tendons. But other tissues participate in this increased development: the bones in particular are, according to Haller, larger and heavier, and have their processes more prominent and strongly marked, furnishing a more powerful leverage to the muscles.

When we compare men with each other in these respects we find the inequality just noted most conspicuous in those that take much muscular exercise. It is more strongly marked, for instance, in the husbandman or the blacksmith than in the clerk or the shopman, while it is least of all apparent in those that lead an indolent and inactive life.

Among women there is less inequality of the two sides than among men. But the diversity occasioned by age is the most striking. The inequality which is so marked in the man is less perceptible in the stripling, and still less so in the boy. In the child it is still more faint, and during infancy and the fœtal state it is no longer to be discovered.

With respect to the use which we make of the limbs of the two sides, here, as everywhere else throughout the wide domain of physiology, we find action corresponding closely to structure. The tendency to use the right hand, or, which is nearly the same thing, the habit of using it, as well as its superior strength and efficiency, or what we emphatically call *dexterity*—these are always proportionate to the development of the muscular system. This, at least, holds true of adults and of young persons, and even of children of vigorous frame; but among the less vigorous we often see a habit of using the right hand

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which we could not have inferred from the condition of the muscular system, and which is manifestly a voluntary habit, acquired by precept and example, or the desire to avoid the imputation of awkwardness, or, as the French name it, *gaucheté*, which we associate with the use of the left hand.

As to infants, again, it will, I think, be admitted by all observant persons that they exhibit no tendency to use the one hand in preference to the other, as they employ indifferently the nearest hand to clutch at any object within their reach. Even in childhood the two hands are often used indiscriminately. This is more especially the case with weakly children, with whom it requires great attention to make them relinquish the bad habit of using the left hand, which it is supposed they have contracted. But this is a mistake, and an error in physiological training founded upon it. Nature intends all the limbs to be equally exercised during the weakness of infancy and childhood, and it is wisest to allow the development of all the parts of the frame to proceed in the natural way without interference. It will be shown below that as soon as a child acquires such a degree of vigour of muscle and firmness of bone as to enable it to put forth the whole strength of its body—then a mechanical advantage necessarily accrues to the muscles of the right side, and the child becoming conscious of the superior power of those muscles, soon learns spontaneously to call them into action; but until that feeling arises naturally, and prompts to the use of the muscles of the right side, it is to do violence to nature, and to dwarf the left side of the body, to enforce upon a child the use of the right.

It thus appears that the preferential use of the right hand is not a congenital but an acquired attribute of man. It does not exist in the earliest periods of life, but shows itself sooner or later thereafter, according to the development of the muscular and osseous systems.

To the general rule, however, that men prefer the right hand to the left, there are, as to most others, certain exceptions. Some individuals continue during boyhood, and even during their whole lifetime, to use the left hand as readily as the right, and with a strength and endurance little, if at all, inferior. Such persons we call ambidextrous. But in some men a still greater anomaly prevails, for they are truly left-handed. In them the left hand takes the place of the right, being more highly developed and stronger, as well as superior in the address and efficiency which we name dexterity in the other hand.

Among some nations of antiquity the custom seems to have prevailed of cultivating the use of the left hand on account of its utility in war. Thus we read in the Old Testament (Judges xx. 15, 16,) that in the

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tribe of Benjamin, out of 26,000 men that drew sword there were 700 chosen men left-handed, of whom every one could sling stones at a hair-breadth, and not miss. This gives a proportion of nearly 3 per cent. (2·69) of left-handed men; and as this is a proportion much greater than obtains in other communities of men, it is obvious that the great number must have been the result of education, and it may be inferred, without improbability, that the majority of them must have been ambidextrous, rather than left-handed. No training, indeed, could ever render the left hand of ordinary men equal in strength to the right; all that can be done being to diminish the inequality. A person really left-handed, or having the left hand stronger than the right, is much more rare, and the proportion of such men in all communities is probably nearly the same. What that proportion is I do not know. Among my own schoolfellows and companions in boyhood I recollect only one whom I regard as having been truly left-handed. But there were several who were ambidextrous. Among boys personal prowess and the *virtus bellica* are held in high repute, and they often cultivate the use of the left hand from the idea that it makes them good fighters. This is quite analogous to what takes place in the rude ages of human society, and serves to illustrate the doctrine that, just as it is shown in physiology that the human organism, in the course of its development, exhibits a series of phases comparable to those observed in the bodies of animals scientifically arranged in a zoological scale, so it is shown in history that the human mind passes through certain stages of development which find their anti-types in the progressive stages of advancement of human society.

II. Explanatory Hypotheses.—The hypotheses which have been formed to explain the inequality in size and strength of the two sides of the body may be divided into two classes, according as they assume increased nutrition or increased muscular action to be the primary differences between them. If it can be shown that the right side of the body is better nourished than the left, then will the muscles participate in that better nutrition; they will therefore be more fully developed and stronger than those of the opposite side; and, as a consequence, they will be more frequently exercised, which will still farther increase their nutritive development. But, again, if it can be shown that, from any cause distinct from increased nutrition, the muscles of the right side are more frequently called into action than those of the left, then, just as in the former case, will the whole phenomena be easily explained, for it is a well-known law which regulates the nutrition of the muscular tissue, that it is the more developed the more frequently and energetically the muscles are exercised.

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A. **Higher Nutrition.**—Those who advocate the hypotheses of the former class, and assume that increased nutrition of the right side is of primary occurrence, regard that increased nutrition, either as springing immediately from a law of development of the muscular tissue of the right side, or as resulting in a secondary way from the condition of certain other organs capable of influencing nutrition.

It is quite conceivable that a law of development might directly influence the condition of the muscles, as of any other tissue, on the right side of the body, rendering them larger than the corresponding tissues on the left side. It is not more difficult to conceive this than the known physiological fact, that while in most other animals the organs of generation are developed symmetrically on both sides of the body, in birds they are developed on the left side alone. But it is not enough to show that this hypothesis is not repugnant to the laws of nature. It must be shown also to be in accordance with them; and here the argument fails; for a law of nutritive development would most probably have been apparent from a very early period, even in the embryo, and become gradually more manifest as growth advanced; or it would have been linked with particular periods of life, as is the case with the genital organs in both sexes at the period of puberty, and in the female also at the cessation of childbearing life. But the unequal development of the muscles on the two sides of the body is neither congenital nor linked with any particular period of life, but is manifestly contingent, both for the period of its appearance and for its progress, on the functional activity of the muscles.

The same arguments are opposed alike to the hypothesis by which the phenomena are referred to the origin, size, or distribution of the blood vessels, whether arteries or veins, on the two sides of the body. It is, besides, very difficult to see how at any period such causes could produce the effects ascribed to them. So far as any difference could result from the different modes of origin of the arteries, it would be confined to the upper limbs; and no explanation is thus given of the difference of the lower limbs. As to the influence of the veins, it might have been passed over in silence had it not been deemed worthy of a special notice and exposition by Dr. Barclay. His views may be gathered from the following notes, taken from his lectures:—"The veins of the left side of the trunk and of the left inferior extremity cross the aorta to arrive at the vena cava; and some obstruction to the flow of blood must be produced by the pulsation of that artery. From this circumstance Dr. Barclay endeavours to explain why man, as well as other animals, use the right side of the body, particularly the extremities, more than the left. All motions produce obstruction of the

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circulation, and obstruction from this cause must be more frequently produced in the right side than in the left, owing to its being more frequently used. But the venous circulation on the left side is retarded by the pulsation of the aorta, and therefore the more frequent motions of the right side were intended to render the circulation on the two sides uniform." An admiration for his Teacher little short of veneration did not prevent the pupil by whom these notes were taken from appending to them the following criticism:—"This is substituting a final for an efficient cause, and, besides, does not apply to the upper extremities."

B. **Precedence in Exercise of Muscles.**—The hypotheses of the second class have this antecedent probability in their favour, that they are simple and adequate, in the principle on which they are founded, to the explanation they are intended to give. Let it be supposed that the two sides of the body were, by their original constitution, perfectly equal: then, so long as there was no tendency to use the one side more than the other, the same equality would subsist between them; but if at any time a tendency were to arise, from whatever cause proceeding, to use the one side in preference to the other, there would occur also immediately thereafter a gradual increase in the nutritive development and power of the muscles of that side; but the feeling of increased power thus engendered would increase the tendency to call into action the more highly developed muscles, which would be followed by a farther augmentation of their development and power; and thus, these two causes reciprocally augmenting each other, out of the mere tendency to use the one side, there would arise a confirmed predominance of that side over the other. The two sides of the body, and the tendency to exert them, may be not unaptly compared to the two limbs of a syphon and the current of water passing through them. If the two limbs and two columns of water within them be of the same length, the water requires to be impelled to pass through either of them; but if the one be made a little longer than the other, the current of water sets spontaneously in the direction of the longer limb.

It follows from what has been said, that, to explain the greater power and development of the muscles of the right side of the body, it is only necessary to assign a sufficient reason why, among mankind generally, those muscles should be more frequently called into action than the muscles of the left side.

Passing over, as devoid of all evidence in support of it, the supposition that there is any law of innervation, or any peculiarity in the size, structure, or mode of disposition of the parts of the nervous system, in connection with the right side, to which the greater tendency to

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action in the muscles of the right side could be attributed, I proceed to examine two other suppositions,—the one, that the use of the right hand is a human institution or conventional arrangement among mankind; the other, that it depends upon mechanical laws arising out of the structure of the human body.

As to the former of these hypotheses, it cannot, I think, be doubted that the voluntary use of any set of muscles, from whatever motive adopted, and although proceeding from a purely psychological cause, would, if habitually persisted in, signally influence the physical condition of those muscles both in structure and endowments. If, then, we suppose that the two sides of the body were naturally quite equal in point of muscular power, but that the right side were to be systematically and habitually used in preference to the left, the consequence would be that the right side would thereby acquire a higher power and development, that the feeling of conscious strength so engendered would confirm and render easy the habit of employing it, and that the conjoined operation of these causes would be amply sufficient to produce, in course of time, a marked predominancy of the right side over the left. To solve the whole problem, therefore, we have only to suppose that our first progenitors, moved by certain reasons which seemed to them good, showed the example of using the right hand—as, upon different grounds, I have no doubt they did—and farther, that they inculcated the same practice upon a docile and obedient posterity.

This hypothesis, then, is a plausible one, as it affords a satisfactory explanation of some of the most important phenomena to be explained; but it does not explain the whole of them, as it would have done had it been a true interpretation of nature. In particular, it gives no explanation of the universality of the predominancy of the right hand. Uniformity in their operation is the character of physical causes; variability, of moral causes;—the former resting upon the immutable laws of physics; the latter upon human judgment, passions, and caprices, manifested in minds widely different and ever varying. If the use of the right hand were a mere conventional arrangement, founded on utility or expediency, it would have varied, like every other human institution left to voluntary control. Love of change, fancied utility, the spirit of opposition, and mere caprice, would, in every age of the world, have rendered the use of the one hand as common as of the other. If the barbarians who tatoo their faces, compress their skulls, distort their feet, and otherwise mutilate and disfigure the human frame, are, nevertheless, all of them just as unanimous as civilized nations in the preference of the right hand over the left, we may rest

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assured that it is not a mere matter of choice on their part which hand they ought to prefer.

The theory, then, which ascribes the use of the right hand to example and precept, and its higher power and development to the habit of using it, although plausible at first sight, as explaining some of the most remarkable phenomena, is found, nevertheless, on more minute scrutiny, to be beset with insuperable objections. Some cause subject to the never-varying laws of physical nature, and independent of all voluntary control, could alone produce a habit so nearly universal. The remainder of this memoir will be devoted to show that it is the result of mechanical laws, arising out of the organic relations of the two sides of the body, and the inclination of the common centre of gravity to the right side determined thereby.

III. MECHANICAL THEORY.—The view which I take of the origin and causes of the predominancy of the right side is as follows:—I believe that there is no primary or congenital difference in power and development between the two sides of the body; for this is what we observe in infancy and early childhood. But no sooner does the child acquire sufficient vigour of muscle and firmness of bone to be able to put forth the whole strength of his body, than he becomes conscious that his right side is more powerful than his left. So long as he uses his limbs as mere appendages of his body, and separately from it, he uses those of either side with a like efficiency; but when he becomes capable of making all the muscles of his frame—of trunk and limbs—co-operate in producing a combined effort, which nature prompts him to do as soon as he has strength to accomplish it, then for the first time he becomes conscious of the superior power of his right side—a power not primarily due to any superior force or development of the muscles of that side, but to a purely mechanical cause. He cannot put forth the full strength of his body without first making a deep inspiration; and by making a deep inspiration, and maintaining afterwards the chest in an expanded state, which is essential to the continuance of his muscular effort, he so alters the mechanical relations of the two sides of his body that the muscles of his right side act with a superior efficacy; and to render the inequality still greater, the muscles of the left side act with a mechanical disadvantage. The consequence is, that the muscles of the right side are called into action in preference on all great occasions where muscular power has to be put forth; and, from being more frequently exercised, they become more highly developed, stronger, and more prompt to action. The full predominance of the right side is thus ultimately established. One limb of the syphon has been made longer than the other, and the whole current sets in that direction.

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With the view of establishing this doctrine I shall first endeavour to prove certain preliminary propositions with respect to the position of the centre of gravity of the body, the changes in the position of it produced by the act of respiration, and the connection between the act of respiration and muscular exertion; and I shall thereafter point out the mechanical principles which render the inclination of the centre of gravity of the body to the right side the primary cause, and at all times one of the principal causes, of the superiority of the limbs of the right side over those of the left. The whole argument thus divides itself into two parts, the proof of the first of which is chiefly experimental, or derived from general reasoning, while the proof of the second is chiefly demonstrative. But I shall add a third part, containing some evidence not strictly belonging to either of the former heads, or omitted in its proper place, not to encumber the general argument.

A. Preliminary Propositions.

1st. *The centre of gravity of the body situated not in the mesial plane, but to the right side of it.*—Borelli found the centre of gravity of the body to be situated between the hips and the pubis, or in the middle of the pelvis. His experiment was made by poising a table accurately on the edge of a triangular prism, placed under it *transversely*, and laying thereupon a dead body, which he shifted upward and downward till equilibrium was produced. This experiment could determine only the transverse plane in which the centre of gravity is placed. But to render the investigation complete, it should have been accompanied with another experiment, similarly made with a table poised on the edge of a prism placed under it *longitudinally*, which would determine whether the centre of gravity be situated in the mesial plane or to one side of it.

Weber has of late years repeated Borelli's experiment, with various precautions to insure accuracy. He found the point fixed upon by Borelli as the centre of gravity to be too low. In a man 5 feet 2·329 inches in height (1669·2 millemètres) he found it to be (87·7 millemètres) rather more than one-third of an inch above the promontory of the sacrum. However accurate this determination may be, it is liable to an objection, which applies equally to that of Borelli, that the position in which the body is placed during the experiment makes the weight of the hands and arms tell too much downward; for the hands are stretched out by the sides, and extend downward to the middle of the thighs. This is the position in which a man is laid in his grave, but what is wanted is to determine the centre of gravity in living men during a period of active exertion, in which the body is erect and the upper extremities free, with their whole weight appended to the

shoulder-joints. To determine this with the body recumbent, the upper extremities should be placed on either side in the same straight line, or at right angles to the trunk of the body; the mechanical effect of which, in such an experiment, would be just the same as if the whole weight of the upper limbs were placed in the middle line of the body, at the top of the sternum. Such an arrangement would elevate the centre of gravity of the body nearly as high as the umbilicus.

But no attempt has been made, so far as I know, to determine experimentally whether the centre of gravity of the body be situated in the mesial plane or to one side of it; and in the absence of direct experiment we must have recourse to general reasoning. It cannot, I think, be doubted that in the adult the greater development of the locomotive organs of the right side will cause the centre of gravity to deviate from the middle plane, and incline to the right. In the fœtus, and for some time after birth, the vast size of the liver will give rise to a similar deviation. But in a child from one to two years of age, in whom the liver has diminished in size, and assumed the relations to the other viscera that it is afterwards to retain, but in whom the locomotive system of the right side has not yet acquired a predominancy, it is probable that the two halves of the body, separated by a vertical section from before to behind, differ very little in weight from each other; and in that case the centre of gravity must be situated in the middle plane. Now, it is at that very age, when the child makes his first attempt to walk alone, that he begins to exhibit the tendency to use the right side of his body in preference to the left; which leads me to think that the primary cause of that tendency is the deviation of the centre of gravity towards the right side produced by inspiration, rather than that resulting from any structural difference of the two sides.

2d. *A deep inspiration necessary to every great muscular effort.*— This proposition need not detain us long. All who have studied the science of physiology know that it is essential to every great muscular effort that a deep inspiration should be first made, and that the chest should continue in the expanded state as long as the effort lasts. You know that an animal cannot run, leap, or make any other great muscular exertion if it have an open tube inserted into the windpipe, or if there be anywhere an open wound through which the external air communicates freely with the air passages, because in such circumstances the chest cannot be maintained in the expanded state. You know also the two great ends which are served by the continued expansion of the chest, accompanied as it is with a fixity of the abdominal muscles— to convert the trunk of the body into a firm basis of support for the limbs and contracting muscles, and fully to aerate the blood which is

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to stimulate the muscles and nervous centres during the period of their excitement. I shall advert but to a single circumstance connected with this process, because it has a mechanical significancy, and bears upon our present subject. During certain muscular efforts, as in those which we name expulsive, the included air is retained in the chest by the closure of the glottis, the slender muscles of which are enabled to withstand the force of the much more powerful expiratory muscles by a mechanism which Sir C. Bell has explained. But it is taught erroneously, as appears to me, that the same thing happens in violent exercise of the voluntary muscles, for in these the glottis remains open, the mouth and throat forming a common cavity with the chest, in which the air is retained by the compressed lips and nostrils.

3d. *Shifting of the common centre of gravity of the body obliquely backward and to the right on making a deep inspiration.*—I have endeavoured to show that in the dead body, if the upper limbs be placed so as to produce the same mechanical effect as in active muscular exertion, the centre of gravity is placed a little below the navel, and inclined to the right side. In the living body, so far as it can be said to have any fixed place, it occupies the same point when the lungs are undistended; but upon making a full inspiration, as we have just seen must always be done to prepare for any great muscular exertion, the centre of gravity inclines farther to the right side and backward, nearly in the direction of the right heel, and it remains in this new position as long as the chest continues in the expanded state.

This problem, like that relating to the ordinary position of the centre of gravity of the body, admits of experimental proof, and I have given below (Part C., 1*st*) the only experimental evidence I have to adduce in support of it. I here subjoin some general arguments pointing to the same conclusion.

The right lung is more capacious than the left, having three lobes, while the left has only two, and it receives more air on inspiration, to the extent, as has been estimated, of about one-twelfth. If, therefore, 240 cubic inches be inhaled, which is under the highest *complement* given by Mr. Hutcheson, the right lung would receive 20 cubic inches more than the left. In consequence, the right side of the chest bulges out more than the left on inspiration, as is manifest to the eye; and the lower ribs, as they recede from the middle plane, carry with them the liver, which is firmly bound to them on the right and posterior aspects by its short and strong coronary ligament, while its other ligaments being long and lax offer no impediment to its outward motion. Now, the liver being the heaviest organ of the body, weighing nearly 4 lbs. avoirdupois, to whichever side it swings it will incline the common centre

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of gravity in the same direction. The combined effect, therefore, of greater expansion of the right side of the chest, and the motion of the liver, is to shift the position of the centre of gravity of the body obliquely backward and to the right, and probably also somewhat downward. The inclination of the centre of gravity to the right is not counteracted, as might at first be supposed, by any motion of the heart in the opposite direction, for the heart is firmly attached to the spine and diaphragm by the pericardium, and the expansion of the adjacent part of the lung takes place to the left of it, and often also in front. As to the stomach and spleen, they go with the liver, to which they are attached by veins and by the omentum minus, rather than follow the left ribs, with which they have no structural connection.

4th. *More general view of the utility of the act of respiration in shifting the position of the centre of gravity in subservience to the movements of the body.*—We have shown that when both sides of the chest are equally distended, as in ordinary inspiration, the centre of gravity of the body shifts obliquely backward and to the right, which, for the purpose of our argument, is the most important point to establish. But it tends to confirm and illustrate this, to show also that nature makes use of the act of respiration for many analogous purposes, shifting the centre of gravity of the body in subservience to its intended movements. This is effected by means of the viscera attached to the diaphragm above and below, viz., the liver, heart, stomach, and spleen. These together form a mass of from five to six pounds in weight, which, as it is carried by the motion of the diaphragm upward or downward, or inclined to either side, backward or forward, cannot fail to influence the position of the centre of gravity of the body. Every energetic muscular action has a peculiar mode of respiration, which we instinctively combine with it, and the main object of which is to adapt the position of the centre of gravity of the body to the motion to be performed. Thus, in preparing for violent exertion with the right hand, instead of inflating the two sides of the chest alike, the left side is contracted and the right side distended to the uttermost, which has the effect of shifting the centre of gravity, in the direction indicated above, farther than an ordinary inspiration can effect. In using the left hand again, the left side of the chest is fully distended, while the right is only moderately distended above, and below it is contracted and inclined to the left, so as to force the visceral mass in the same direction. In preparing to leap upward, as upon a chair, the centre of gravity is elevated, the visceral mass being forced upward by the contraction of the abdominal muscles, while inspiration is made altogether by the dilatation of the ribs without any depression of the diaphragm. But

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in leaping down again the inspiration is chiefly made by the depression of the diaphragm, which lowers the visceral mass and centre of gravity.

Still farther, the respiratory muscles, during the continuance of any muscular effort, adapt themselves to the necessary change in the position of the centre of gravity, and thus facilitate the effort. In throwing a stone the centre of gravity advances forward and to the left, being over the right heel at the commencement of the act, and over the right foot at the end of it; and, correspondingly, it will be found that while the right side of the chest was dilated and the left contracted at the beginning of the act, it is the left side which is dilated and the right which is contracted at the end of it; even in the mouth it will be often seen that the right cheek is inflated at the beginning and the left at the end; and all these changes take place by the mere movement of the air within the chest and upper air passages, without any fresh act of respiration. It is otherwise, however, if the effort made be beyond the strength of the individual making it, for then the air rushes forth with a loud sighing noise, as we hear in the paver and the man who wields the sledge hammer; and so great is the force with which the air rushes forth, that the attempt to confine it is often followed by deplorable consequences, as I have myself witnessed.

5th. *The kind of respiration which accompanies the action of the limbs of the right side more favourable to sustained muscular exertion than the respiration which accompanies the action of the limbs of the left side.*—The respiration which accompanies the action of the right side is free and nearly natural, while that attending the action of the left side is constrained and with much less amplification of the chest; so that the aeration of the blood and consequent excitation of the nervous system and muscles must be effected more completely in the former case than in the latter.

B. The inclination of the centre of gravity of the body to the right side confers a mechanical advantage on the limbs of the right side in their complex movements, while it is mechanically disadvantageous to the limbs of the left side in the analogous movements which they perform.

This proposition embraces the whole of the mechanical or demonstrative part of this argument. It is too general to admit of proof without being divided into several subordinate propositions; and these must be preceded by what mathematicians would name a lemma, explanatory of the principles on which we can compare together the muscular actions of the two sides of the body, so as to judge of their relative power—that is, to estimate the momentum which they respectively generate.

1*st.* The momentum imparted to the body by its own muscles, in the

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transition from one attitude to another, will be greater or less—(1*st.*) According to the number and power of the propelling muscles; (2*d.*) According to the mechanical disposition of the bones or passive organs of motion; (3*d.*) According as the propelling muscles are in effective action during the whole or only during a part of their range of contraction; and, (4*th.*) According as the resultant force in the direction of which the centre of gravity moves is generated by forces more or less parallel—that is, less or more antagonistic to each other.

The first mode of comparison is chiefly applicable to movements which are dissimilar to each other; for in these it is obvious that the number and strength of the muscles called into action must often differ widely. But they are foreign to our subject; for in comparing together the two sides of the body, we compare movements which are strictly analogous. In these it might at first be supposed that there could be no difference in the number of the propelling muscles on either side. It will, however, be seen below that the predominancy of the right arm over the left is mainly owing to the greater number of muscles that assist in giving it motion.

The second mode of comparison affords demonstrative evidence derived from the principles of mechanics of the relative power of the two sides of the body. It is exemplified below with respect to the movements of the lower limbs in all their varieties.

The third mode of comparison might have been otherwise described as referring to the greater or less length of the line described by the centre of gravity under the influence of the propelling muscles. In all analogous movements the longer this line the greater is the momentum generated, although not in strict proportion. Thus a man will never spring from the ground in a standing posture so high as when slightly bent, nor in the latter posture so high as he can do if he first put himself in the stooping posture which nature and experience teach him to assume for the purpose; and in each of these cases the length of the line described by the centre of gravity, from the point at which it begins to move till the feet leave the ground, serves to indicate the momentum generated. It will be seen that this principle is applied in comparing together the lateral movements of the pelvis on the two sides.

Of the principle involved in the last mode of comparison we may take as illustrations the movements to which it is applied below. We leap farther straight forward than with much inclination to either side: but we leap farthest of all with a slight inclination to the left side; for the centre of gravity has the greatest range in that direction, under the influence of the muscles acting on the pelvis; and an additional impulse is given to it forward and to the left, by the transition of the

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thorax from the state of inspiration to that of expiration, which transition accompanies the act of leaping with full force; lastly, the propulsion on the right side is more powerful than on the left.

2d. *Comparative Power of the Lower Limbs.*—The simple movements of the lower limbs present no difference on the two sides of the body in the mechanical conditions under which they are performed. They are therefore excluded from our present inquiry, which relates only to those complex movements in which the lower limbs communicate an impulse to the whole body; and we are to compare the impulse communicated by the muscles of the one side with that communicated by the similarly acting muscles of the other side. As it is to the pelvis that such movements are immediately communicated, we shall speak of them as movements of the pelvis, and we shall consider successively the upward, the lateral, and the revolving movements of the pelvis.

a. Upward Movements.—The upward movement of the pelvis is usually the result of the simultaneous action of the two limbs; but it can be conceived to be produced by one of them only; and we have various practical illustrations of it approaching more or less closely to the theoretical model. When we carry a weight upon either shoulder it is the lower limb of the same side that chiefly sustains the weight. When the carter bears up the shaft of the cart upon his shoulder, or when we apply the shoulder similarly to overcome a resistance from above, the muscular action put forth originates chiefly or entirely with the lower limb of the same side. Now, experience shows that on all such occasions the right shoulder is much more powerful than the left. Neither is this result difficult to explain; for to make either limb act with the greatest mechanical effect it is necessary to make the centre of gravity of the body coincide with the line of direction of the superincumbent weight. Now, upon the right side, the position of the liver and the influence of a full inspiration readily bring the centre of gravity of the body nearly over the right foot, while, at the same time, the joints are in the most favourable position for muscular exertion. But the same two causes have an adverse influence upon the left side; for the centre of gravity cannot be made to come so nearly over the left foot without a kind of respiration and a constrained attitude, little favourable to the muscular action to be performed. (Plate I., figs. 1, 2.)

In fig. 1, Pl. I., the centre of gravity, C, lies in the line of direction of W, the resistance to be overcome, and the muscular power, A C, is applied in the most advantageous direction. In fig. 2, A B is made equal to A C, fig. 1; but the position of the centre of gravity is not at B, but in C′ C″ C‴, &c., when, to produce the same mechanical effect, an amount of muscular power must be put forth, indicated by the lines A B, A C′, A C″, A C‴, &c., continually increasing as the centre of gravity is farther from B.

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It sometimes happens that the upper extremities receive the credit of muscular exertions which are in reality made by the lower. Thus, in the action just described, the shoulder appears to play an important part, while it is, in fact, no more than the end of the shaft set in motion by the muscles of the lower limbs. In the same manner, in lifting a heavy weight from the ground, the arms appear to be the most important agents, while in reality they are, for the most part, like mere inert ropes by which the weight is suspended, and the force which acts through them is derived from the lower limbs. The act of lifting a weight, although apparently so different, is quite analogous to the act last described, in the mechanism by which it is performed. It may be performed either with both hands or with the right and left singly. It thus becomes an excellent means of testing the relative power of the two sides of the body. The weight suspended by the arm from the shoulder has the same mechanical bearing as if placed upon it; and the principles explained above show that the action must be performed most effectively by the muscles of the right side.

b. Lateral Movements.—The pelvis may be impelled towards either side by the limb of the opposite side; and in any direction, transverse from either side, or oblique from behind forward, or from before backward. To produce such a movement the limbs are separated from each other, the impelling limb being more or less bent, and the opposite one extended. On straightening the limb the centre of gravity is impelled to the opposite side with an inclination at first upward and then downward. The first half of the movement is produced by the power of the muscles alone, the second by that power acting in conjunction with the weight of the body; the resulting movement being in the diagonal line intermediate between the direction of the two generating forces.

Of all of these lateral movements that which is practically the most important, and which is also the most extensive in its range, and generates the greatest momentum, is the movement obliquely forward and to the side in a line intermediate between the transverse and antero-posterior diameters of the pelvis. The foot of the side towards which the motion is made is advanced in the line just described, while the other foot is placed sideways behind, and, as in all the lateral movements, the centre of gravity rests over the one foot at the beginning of the movement and over the other at the end of it.

When we compare the lateral movements originating on the right side with the analogous movements originating on the left, we find the former to possess a mechanical superiority over the latter. This superiority is mainly due to the position of the liver; for as this weighty

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viscus is situated on the extreme right, and the body advances sideways, it must manifestly be in front in the motions towards the right side, while it is behind in the motions towards the left. Now, a double mechanical advantage accrues to the right side from this cause. In the first place, to produce lateral movement, the previous flexion of the joints of the impelling limb is required; for it is by the extension of them that the impelling force is produced, and of these joints the hip joint is the most powerful. Now, from the position of the liver over the right hip joint this joint admits of being bent while the body inclines towards the left side, without disturbing the favourable position of the centre of gravity, and thus the powerful muscles of the hip joint exert their full force upon the right side. On the left side, again, from the liver being situated on the opposite side of the centre of gravity from the hip joint, the body cannot be inclined to the right without a displacement of the centre of gravity in the same direction, and thus the flexion of the left hip joint cannot take place without making its muscles act at a mechanical disadvantage.

In the second place, the centre of gravity moves farther under the action of the muscles, without interfering with stability, in its course from right to left than in that from left to right. In either case, the weight of the body as it moves forward comes to be thrown from the foot behind to the foot in front; but the movement from right to left may be carried as far as the power of the muscles and flexion of the left limb in front will admit, for the weight of the liver behind keeps the equilibrium stable, whereas the movement from left to right is prematurely arrested, for the liver being in front renders the equilibrium unstable, as the line of direction sooner approaches the limit of the basis of support.

These arguments, deduced from the mere position of the liver, without reference to the act of respiration, are rendered more forcible by taking into account the influence exerted by the respiration on the mechanical condition of the body. (Figs. 5, 6, 7.)

In fig. 5, Plate I., the line A B C represents the direction of the lateral movements of the pelvis ascending from A to B and descending from B to C. In fig. 6 the oblique force A C B is resolved into a horizontal portion, C D, which carries the pelvis to one side, and a portion, D B, directed upward. But in fig. 7 the direction, C D, is obliquely downward, and the force of gravity conspires to augment the impetus of the body.

In the oblique lateral movement of the pelvis we have another instance of an action performed by the lower limbs being often ascribed to the upper. This happens when a pole or other weapon is held in the two hands in the same way in which a musket is held in a charge of bayonets—that

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is, when the weapon is supported by the two hands horizontally in the plane of the centre of gravity, or nearly so, and in a direction obliquely forward from right to left. This is the very direction in which it has just been shown that the right limb impels the body most forcibly, and the whole of that force is communicated to the advancing weapon, which the hands merely sustain without giving it any additional impulse. This is the case when the hands are pressed close to the body, but when they are protruded forward, as is likely to happen in warfare, they give new force to the weapon.

c. Revolving Movements.—The pelvis may be impelled by one limb so as to revolve horizontally, or nearly so, upon the other; the centre of revolution in the latter being the head of the femur, or some part of the foot—the fore part of the sole, the toes, or the heel: while the movement is for the most part rendered more complicated by the ankle joint passing from a state of extension to flexion, and the hip joint from a state of flexion to extension. But in all its varieties of form this revolving movement is performed more effectively and more steadily by the impulse of the right limb than by that of the left. The reason of its being more effective is very obvious; for the centre of gravity, lying towards the right side, and being farther impelled in that direction by inspiration, the muscles of the right side act with a longer lever and proportionally greater power than the muscles of the left side. Its greater steadiness, again, is owing to the position of the liver at the outer extremity of the radius of curvature, which, by its centrifugal power, acts like a regulator. On the left side, on the contrary, the position of the liver, at the inner extremity of the radius, tends to render the movement insecure. (Figs. 3 and 4, Pl. I.)

In figs. 3 and 4, Pl. I., A is the centre of revolution on either side, C and C′ are the centres of gravity, and R C R, L C′ L are the directions in which the centres of gravity are made to revolve by the right and left limbs respectively; giving a mechanical advantage to the former over the latter as A C to A C′.

3d. Comparative Power of the Right and Left Arms.—There is a much more signal inequality of power between the upper than between the lower limbs. It is also quite different in nature from that which we have described above as existing between the lower limbs. But it does not belong to the upper limbs alone, for the lower limbs participate in it, and generally the two sides of the body, although in so saying it is necessary to distinguish the two sides of the body in a somewhat different sense from that in which we distinguish them as separated symmetrically by a mesial plane.

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When we compare together the simple movements performed on the two sides of the body, at the several articulations both of the upper and the lower limbs, we find no inequality between them, except what may arise from a difference of power in the muscles; for the mechanical conditions under which each joint moves on the two sides of the body are exactly the same. Thus it is with the movements of the two upper limbs in their totality, as performed at the shoulder joints; for whether these movements consist in flexion in any given direction, in rotation, or in circumduction, the mechanical conditions under which they are performed are precisely similar. The same holds of the movements at the hip joints, so long as the trunk of the body has no participation in them, but acts merely as a basis of support to the limbs. But we found it to be quite otherwise in the complex movements in which the body participates; for in these we found that the right side had a mechanical advantage over the left. Now the same holds true of the upper limbs; for it is only in the complex movements in which the trunk of the body participates largely that the right side has a mechanical predominance over the left.

The movements in which the right arm predominates most signally over the left are those in which it is made to describe a curve from behind obliquely forward and to the left, as in throwing a stone or other missile, or striking a blow with the fist or with a weapon held in the hand. The arm is extended more or less in these movements, chiefly according to the weight with which it is charged; but, overlooking at present all lesser differences, we select as an example of these, and of other kindred movements, the throwing of a stone of such moderate size that it can be held at arm's length without inconvenience. The arm is extended to the uttermost, and the hand holding the stone, as it revolves rapidly round the body, describes a curve, which we shall see reason to believe, in the case of the right hand, to be a cycloid. Now, while this movement is performed with ease and effectively by the right hand, it is performed much less perfectly and with difficulty by the left —the act being accompanied with a feeling of constraint and impediment, and sometimes with insecurity in the positions into which the body is apt to be thrown.

With the right arm a stone is thrown most forcibly in a direction obliquely forward and to the left. The left foot is advanced in that direction, with the ankle, knee, and hip joints fully extended. The right foot is placed behind, nearly at a right angle to the left, and with the joints just named all slightly bent, to be in readiness to give an onward impulse to the body. The head rests over the right shoulder, with the eye fixed steadily on the object aimed at; the trunk of the body, as well

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as the head, are thrown backward and to the right; the right arm with the hand holding the stone, is extended to the uttermost in the same direction, while the left arm is bent across the neck. This attitude and a deep inspiration, made preparatory to the muscular effort, cause the centre of gravity to rest over the right heel, without any constraint to impair the power of the contracting muscles or organs of respiration. Such a complicated arrangement would be unnecessary were the arm to act alone, merely swinging in a circle round the shoulder joint; but instead of that the whole body revolves, the arm merely participating in the movement. The axis round which the body revolves is not its symmetrical axis, but its true mechanical axis, as it may be named, coinciding with the line of direction (*linea propensionis*) —that is, with a plumb-line let fall from the centre of gravity, and produced upward. Around this axis the whole body revolves, the right side and arm advancing, while the left side and arm are carried backward,—the left arm having at the very first been brought rapidly forward, and outstretched to the uttermost on its own side, to counterbalance the right arm. Were the axis of revolution quiescent, a circular motion of the arm would be the result; but instead of this the axis moves forward and to the left, impelled by the right lower limb, till it terminates its movement over the fore part of the sole of the left foot, or a step farther forward still, over the right foot, which has in the meantime swept rapidly round from behind to before. Now, as the arm continually revolves round this advancing axis, it will describe a cycloid in its course. There is scarcely a muscle in the human frame which does not take a part in this complicated movement—the right and left sides revolving in opposite directions, and thus co-operating in the impulse they communicate; and it is worthy of remark, that the direction in which the centre of gravity is made to move, obliquely forward from right to left, is precisely the direction in which it has been shown that the right lower limb acts with most mechanical effect, whether it retain its place behind or revolve to the front. Hence it is clear that the superior power of the right arm is not due to the muscles of the arm alone, but to numerous muscles on both sides of the body co-operating with them in a direction highly favourable to their mechanical effect. (Plates II. and III.)

Plate II. represents three successive stages in the act of throwing a stone according to the method first described above, in which the toes of the right foot remain in the same position at the end as at the beginning of the action. Fig. 1 represents the position at the beginning, fig. 2 in the middle, and fig. 3 at the end of the action.

Plate III., fig. 1, represents the attitude of the body at the end of the second method of throwing the stone above described, in which the right foot performs a semi-revolution round the left, and so advances in front of it.

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Plate III., fig. 2,* represents the attitude of the Discobolus, or discus-thrower, from the well-known antique statue in the Vatican. The right arm and left leg are thrown back, to balance the upper part of the trunk, which stoops forward, with an inclination to the right; the centre of gravity is thus thrown over the right heel, and the whole body turns on its mechanical axis, as the right arm performs somewhat more than half a revolution round it in discharging the discus. The modern method of throwing the quoit is different, bearing much the same resemblance to throwing a stone in the ordinary way that the ancient method of throwing the discus bears to what school-boys call *haunching* a stone.

The mechanical conditions favourable to the right arm are no longer of advantage, or are reversed, when the same action comes to be performed with the left arm. The centre of gravity of the body has no natural tendency toward the left side, and, when a deep inspiration is made, swings away from it backward and to the right. A peculiar kind of inspiration therefore, already described, requires to be made to regulate the position of the centre of gravity; but it is of a kind less favourable to muscular effort than the ordinary inspiration, and, moreover, cannot be maintained as the body advances forward, when the centre of gravity again inclines to the right side. There is, therefore, no longer the same harmony between the two sides of the body revolving round a common axis; the left arm, compelled to rely more on the action of its own muscles, swings round the shoulder in a course more nearly circular; and less aid is derived from the left lower limb, which has been already shown to propel the body at greater disadvantage than the right. The causes, therefore, are manifest which impede the action of the left arm, and produce the awkwardness and constraint, and the occasional instability with which it is accompanied; the kind of respiration required being less favourable to muscular exertion, the two sides of the body not balancing each other, nor revolving harmoniously round a common axis, the arm acting chiefly by its own muscles, and the lower limb assisting it less powerfully.

4*th. Burdens best carried on Left Side.*—I have reserved to the last the notice of the only instance I know in which there is a mechanical advantage in the use of the left side, and in which that side is in consequence used in preference to the right. Carrying or supporting burdens is the special function of the left side. Look at the women who go along with baskets of eggs or vegetables. They all carry the baskets on their left arms. The nurserymaid carries an infant on her left arm. If you ask her the reason, she can probably only reply that she was instructed to do so, or that all other nurserymaids do the same. But if you ask the same question at an intelligent mother in the humble

*** For the photograph from which this engraving has been taken, and which was made from a cast in the gallery of the Government School of Art in this city, I am indebted to the kindness of Charles Heath Wilson, Esq.**

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Movements effected by Lower Limbs

Upward Movements

Fig. 1.

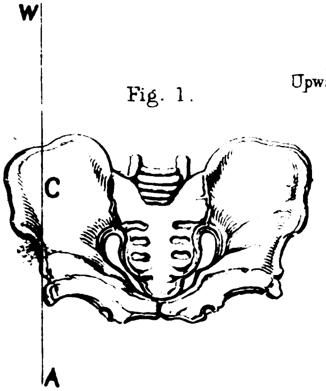
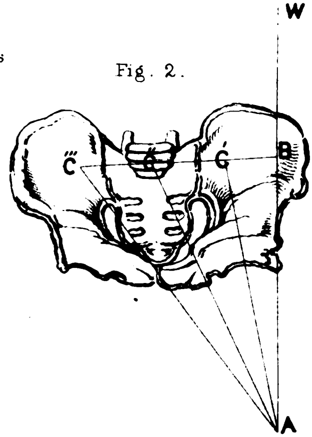


Fig. 2.



Revolving Movements

Fig. 3.

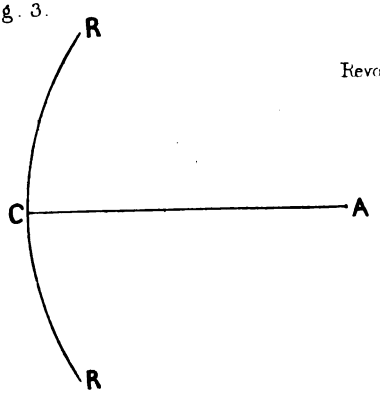
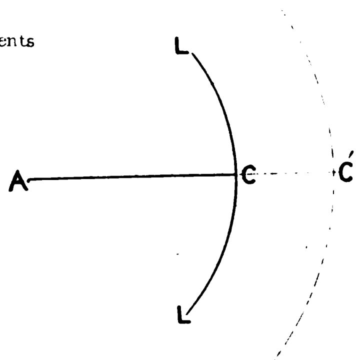


Fig. 4.



Lateral Movements.

Fig. 5

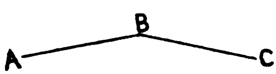


Fig. 6.

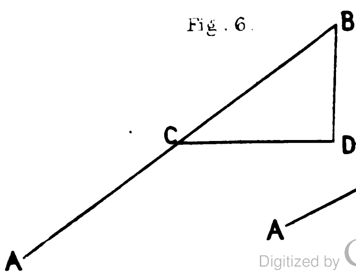


Fig. 7.

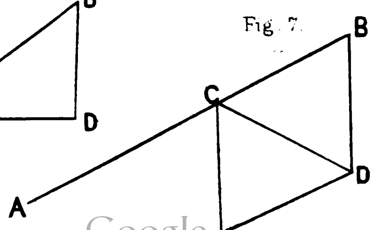


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Plate II.

Fig. 3.

Third Attitude

Fig. 2.

Second Attitude

Fig. 1.

First Attitude

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Fig. 3.

[illegible] Shoulder

Fig. 2.

Throwing Discus

Fig. 1.

Throwing Stone

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ranks of society she will tell you that she must keep her right arm free for the older children, and for her various household duties. Her view, then, is, that it is on account of the comparative uselessness of the left arm that it is set to sustain burdens, and so leave the right arm free for its more important duties. This is true in so far, but there is besides a mechanical cause which is overlooked. A different reason certainly must be given why the porter hoists a heavy trunk or the carter a sack of meal on his left shoulder, for the burden demands his whole strength, and the right arm acts the part of a mere auxiliary to the left.

There are two mechanical reasons for the preference given to the left side in carrying burdens; the one applying to light weights swung upon the arm, the other to heavier weights borne upon the shoulder.

In carrying a weight not heavier than can be borne upon the arm, the equilibrium of the body is better maintained by carrying it on the left side; for the centre of gravity being upon the opposite side, less inclination of the body to that side is required when the weight is appended to the left; and there is, therefore, less interference with the natural play of the limbs in walking: whereas, if the weight be appended to the right by the side of the liver, the body must be thrown very much to the opposite side to keep the equilibrium stable, and the motion of the limbs will be proportionally constrained.

The mechanical conditions under which a man bears a heavy weight upon his left shoulder are quite different, and still more worthy of admiration. The burden is in reality supported, not by the left, but by the right lower limb. The body is inclined to the right side, as described above with respect to the act of throwing a stone, so that the mechanical axis passes from the left shoulder to the right foot, and the load is placed right upon the top of it, the whole force of the right arm being employed to place it there.

In this way the muscles exert their full force effectively in sustaining the load, while the body is so disposed that it can revolve freely on its mechanical axis, which is of great service in adjusting and throwing off the load. But there is a still more wonderful adjustment; for the centre of gravity is so placed that the body can revolve also with ease and the full force of the muscles on another axis passing through the centre of gravity at right angles to the former. By this kind of revolution the weight can be thrown off the shoulder to the left or over the head to the right with as much ease as it can be thrown backward or forward by the revolution first described.

The left side may therefore be compared to a "beast of burden," the offices of which it is fitted by a special mechanical adaptation to perform. The right side is like the horse—prompt, rapid, powerful, and graceful in

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its movements; while the left is like the camel—less ready, and more slow and awkward, but bearing its burden indefatigably, and stooping to receive and to be released from its load. (Plate III., fig. 3.)

Plate III., fig. 3, represents a burden borne on the left shoulder at the summit of the mechanical axis passing along the right lower limb, while the body is capable of revolving either on this vertical axis or on an axis at right angles to it, and intersecting it in the middle of the loins.

To recapitulate, I have shown that the greater development of the muscles of the right side is owing to the more frequent use made of them; and that this more frequent use, although in part proceeding from their greater development, is originally altogether independent of the condition of the muscles, and due to a mechanical cause inherent in the constitution of the human frame—the position of the centre of gravity to the right of the mesial plane, and the farther inclination of it backwards and to the right on deep inspiration, essential to muscular effort; and lastly, I have explained in what way the position of the centre of gravity operates in giving predominancy to the limbs of the right side.

C. **Additional Illustrations.**—To these arguments, deduced chiefly from the principles of mechanical science, I shall add one or two, chiefly of an experimental kind, which address themselves to our senses or conscious bodily feelings, or to the common experience of mankind.

1. The first addresses itself to the sense of sight, and exhibits one of the marvels of the human mechanism. When the body stands erect on the two feet, while the posture is stable and secure, the various parts of the frame, if not voluntarily restrained by the action of the muscles, preserve their mobility with respect to each other, and yield lightly and gracefully to the slightest impulse, like a tree fast rooted in the ground, while its branches quiver in the breeze; or like a ship held fast by its moorings, while it rocks lightly on the waves. A floating body is indeed the best similitude. A light boat floating in the water changes its position with every change of its centre of gravity, such as would be occasioned by a person in it moving from one place to another. A cart or waggon resting on dry ground would be quite uninfluenced by a similar cause; but we see an approach to it in a well-hung carriage, the springs of which yield in correspondence with the position of the persons within it. Now, the human body, placed as we have supposed, is supplied with numerous delicate springs that connect its several parts, as between the toes and bones of the feet, and at the ankles, knees, hips, and joints of the spine; and so lightly and delicately is it poised, that every movement of its centre of gravity produces involuntarily a perceptible change in its position. Thus it oscillates with the act of

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breathing; when the centre of gravity shifts during inspiration, it inclines to the right side, and it returns to its former position during expiration. This oscillation is best seen in our own persons, because its correspondence with the conscious acts of inspiration and expiration serves to guide the eye of the observer. It may be seen in a looking-glass, or on the shadow of the body fitly thrown on a screen or wall. My attention was first attracted to it in a different way. Looking from my own window at a light in the house opposite, I was amusing myself listlessly by bringing the bar of the window opposite into such a relative position that it might conceal the light at once from both eyes. I succeeded in doing this, but remarked at the same time that the light appeared from time to time. Further observation satisfied me that the appearance of the light corresponded with the act of inspiration, and that it always appeared at the right side. It immediately occurred to me that this phenomenon might be connected with the arduous problem which Dr. Barclay had first taught me to investigate, and which I had ever since pursued with such little success; and arguing from the observed phenomenon upwards to its cause, and from the cause, when once established, downwards to its effects on the movements of the body, I became persuaded that I was on the right road. Such, at least, was the embryo idea conceived last spring. It has since gone through exactly a nine months' process of evolution, and I now leave it to you* to decide whether it is to be regarded as a mere abortion or shapeless monstrosity, or, if more happily organized, and fitted for independent life, it is to become stronger as it grows older, till it can at length assert its place among the genuine doctrines of physiology.

2. A second argument addresses itself to a peculiar internal sensation, the precise nature of which it is for physiologists to determine.

Let any one compare the strength of his right and left arms while the lungs are in the unexpanded state; let him then make a full inspiration, and he will feel the power of his right arm increase with every cubic inch of air which he inhales, till it attains its maximum, when the inspiration is completed. In the left arm, again, he will perceive little change, so that the disparity between the two arms is increased by inspiration. Or, again, let any one, when the power of his right arm is at its maximum, blow out his breath, and the power will gradually dwindle down to the standard of the left arm.

As to the sensation by which we become conscious of the increasing or diminishing power of the right arm in the preceding experiments, it is manifestly of the same class as those intrinsic sensations which serve

* These words are to be understood as addressed to the medical students of the University, before whom this paper was first read.

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to indicate to us certain conditions of our internal organs—as a hungry stomach, a parched mouth, or a distended bladder. It is most closely allied to those sensations which indicate to us the conditions of the muscular system; but it is not identical with what has been called the muscular sense, for it merely gives to us consciousness of possessing strength, and not of actually putting it forth, of which the muscular sense is the measure.

3. There is less inequality between the two sides of the body in women than in men, which is owing partly to the strictly symmetrical arrangement of the generative organs within the pelvis, and partly to the slenderness of the waist and less breadth between the shoulders. But in civilized society, and more especially among the higher ranks, it is mainly owing to the style of dress which, by contracting the waist, renders useless the apparatus provided by nature for adjusting the centre of gravity in accordance with the movements of the body.

4. After studying the kinds of inspiration which accompany the action of the right and left hands respectively, change the action of the hands without altering the kind of inspiration, when the action of either arm will be signally weakened and impeded.

5. In leaping forward with the whole strength, the body deviates in its course towards the left, for when the whole strength is put forth an expiration is made, and the centre of gravity inclines from right to left: something must also be ascribed to the superior strength of the right foot.

6. Many dogs, but not all, and never at full speed, run diagonally forward with the left shoulder in advance. Birds fly straight, but walk diagonally, which last is probably connected with the lateral disposition of their eyes. Crabs and lobsters advance obliquely.

7. It may be asked, if men use their right hands not from habit but from a mechanical necessity, how it happens that some men use their left hands rather than their right. It seems to me probable that many such cases, as in the left-handed slingers of the tribe of Benjamin, are merely cases of ambidextrousness, where the habit of using the left side, in whatever way begun, has given to the muscles of that side such a degree of development as enables them to compete with the muscles of the right side in spite of the mechanical disadvantages under which they labour. There is an awkwardness in the muscular efforts of such men which seems to indicate a struggle against nature. There are, however, unquestionably, as I believe, men who use their left limbs with all the facility and efficiency with which other men use their right. Pathological anatomy furnishes us with a complete explanation of this anomaly in certain cases. There are men born, who may grow up and enjoy

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perfect health, in whom the position of all the thoracic and abdominal viscera is reversed. There are three lobes of the left lung and only two of the right, the liver is on the left side, and the heart on the right, and so forth. Now, individuals so constituted must use their left limbs most effectively from a mechanical necessity, just as other men use their right. There are other malformations and pathological lesions, particularly those occurring in early life, which must materially influence the relative power of the two sides. Such are diseases of the right lung, contraction of either side of the chest from pleurisy, enlargement of the spleen, particularly when, as often happens, it is accompanied with a diminished size of the liver, distortions of the spine with consequent displacement of the viscera, and many others.*

March 26, 1862.—*The President in the Chair.*

Mr. James Hamilton, 202 Adelaide Place, Bath Street, was elected a member of the Society.

PROFESSOR WILLIAM THOMSON described a new instrument for the absolute measurement of Electric Resistance.

On a New Instrument for Measuring Electric Resistance in absolute Units. By PROFESSOR WILLIAM THOMSON.

IN Weber's admirable system of electric measurement the "resistance" of a conductor, such as a telegraph wire, or the coil of a galvanometer or electro-magnet, is determined without reference to any particular metal or individual standard, by finding the velocity at which a motion inducing electro-magnetically a current in it must take place to produce a certain defined electro-magnetic effect by means of this current. The greater the resistance of the wire to the flow of the current, the greater must be the velocity of the motion. The resistance of a conductor which requires a velocity unity to produce the unit effect is taken by Weber as the unit of resistance. The velocity required to produce the unit electro-magnetic effect in any other conductor measures the "resistance" of the conductor in absolute units. For British electricians and engineers the most convenient unit seems to be one foot per second of velocity. Weber uses the metre instead of the foot; and the reduction of measurement in terms of his unit of electric resistance to the "British absolute unit," is simply the reduction from metres to feet.

The instrument exhibited to the Society is one which has been planned by the author for practically applying Weber's system with greater ease, and if possible also with greater accuracy than has been

* See Note from Aristotle, *De Animalium Incessu*, p. 198.

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hitherto done. It consists of a frame bearing two wide open circular bobbins, each one foot in diameter, and carried at a rapid uniform rate round a vertical axis by means of proper mechanism. A small magnet (about $\frac{1}{4}$ inch long) suspended from a fixed point by a single silk fibre, and bearing a light mirror attached to it, hangs in the centre of the bobbins. Light from a fine vertical slit in front of the flame of a paraffin lamp, or of a suitable gas burner, passes through a convex lense, and is reflected from the mirror so as to produce an image of the slit on a fixed scale. The motions of this image indicate, with accuracy, angular motions, large or small, of the magnet.

When the ends of the wire-coils are left insulated, and the bobbins made to rotate, no deflection is produced. When a closed circuit or circuits are made, by connecting the two ends of each or either coil, or of the two coils connected together in series, or in double arc, the rotation of the bobbins causes the needle to be deflected largely in the same direction as the rotation. When the rotation is so rapid that a great many turns take place in the time occupied by a single vibration of the needle, a nearly steady deflection is maintained by a uniform rotation. The velocity of the rotation required to produce a stated deflection, with proper corrections and reductions, shows the resistance of the circuit of wire in the coils.

The electro-magnetic influence by which this deflection is produced depends (according to Faraday's discovery and law of electro-magnetic induction) upon the horizontal component of the earth's magnetic force; and with the same apparatus and same velocity of rotation, it will be simply proportional to the magnitude of this component, either in different localities, or in the same locality at different times. But the deflecting force required to produce a certain deflection on the needle is also simply proportional to the horizontal component of terrestrial magnetic force. Hence it appears that the amount of the deflection depends on the velocity of the rotation, and on the resistance and configuration of the coils of wire, but not on the amount of the terrestrial magnetic force. A steel magnet in the neighbourhood will therefore not alter the result, provided it is so far from the apparatus that its integral effect on the rotating bobbins does not differ sensibly from that of a uniform magnetic force equal and parallel to that which it exerts at their centre.

Small corrections on the result of an experiment with this apparatus are required to eliminate the effects of the electro-magnetic induction of the suspended steel magnet on the moving coils, and of the virtual electric inertia of the varying currents themselves (or, as it is generally called, the "induction of the currents on themselves").

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PROFESSOR WILLIAM THOMSON made some observations on the Rigidity of the Earth.

On the Rigidity of the Earth. By PROFESSOR WILLIAM THOMSON.

A THEORY of the deformations of elastic spheroids communicated by the author to the Royal Society of London shows that unless the Earth is excessively rigid as a whole—more rigid, for instance, than glass or even than steel—it would yield in its figure to the disturbing influences of the sun and moon to such an extent as to very much diminish the amount of the tides (or rise and fall of the ocean relatively to the land), and of precession and nutation, from what they would be if the Earth were perfectly rigid. Hitherto these phenomena have not been found to present any sensible deviation from what they would be if there were absolutely no yielding of the solid Earth; but that there must be some such deviation is quite certain, and whether it is twenty per cent., which seems scarcely probable, or five per cent., which for all we know at present it may well be, or some smaller fraction of the whole amount, can only be determined when data are available for more rigorous comparisons between theory and observation than have yet been made.

From what is at present known, however, regarding the phenomena of tides, and of precession and nutation, and from the theoretical views now pointed out, it seems most probable that the Earth as a whole is more rigid than steel, and quite certain that it is more rigid than glass. Hence the author concludes that the hypothesis held by many geologists, that the Earth consists of a solid crust of something less than 50 or 100 miles thickness, is certainly false; that Mr. Hopkins' conclusion, that the solid crust is not less than 800 miles thick, is certainly true; and farther, that it is scarcely possible it can be less than 2,000 miles thick.

Even if the Earth is solid to the centre, with only vesicles of liquid lava, such as active volcanoes demonstrate, and which need not be so large as sensibly to influence its rigidity on the whole, the interior parts must contain a vast mass of substance far more rigid than the upper crust, because we know that the rigidity of this, even in its hardest parts, is much less than that of steel, and probably even less than that of glass. That the solid interior, or the solid parts of the interior, at great distances below the surface, should be very much more rigid than the superficial rocks, either as they exist in nature or as we have them in fragments on which we can experiment in our laboratories, is only what we should expect, when we consider the enormous pressure at great depths, and does not require us to suppose that the interior

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consists on the whole, or in great part, of substance which at the same pressure and temperature, would differ much in rigidity from the superficial rocks.

April 9, 1862.—ROBERT HART, Esq., *Vice-President, in the Chair.*

PROFESSOR GRANT read a paper "On the present state of the Theory of the Movements of Comets, considered in relation to the question of the existence of a resisting medium."

April 23, 1862.—*The President in the Chair.*

The following papers were read:—

On the Landslip and Movement of the Moss in Auchengray Estate, Slamannan, on the 12*th and* 15*th of August,* 1861; *illustrated by a Drawing.* Communicated by MR. THOMAS GIBB, Surveyor, Newarthill.

THE accompanying map of the moved moss, and the moor of which it formed a part, with adjoining lands, shows the former positions of the roads, &c., in dotted lines. The moor lies on the north side of the parish road from Caldercrooks, on the Edinburgh and Glasgow northern road, to Slamannan, about midway between these villages, being about 2½ miles from each. The parish road crosses the boundary between Lanarkshire and Stirlingshire at the eastern extremity of the moor.

The central area of 70 acres, marked with the letter A on the map, is the highest part of the moor, excepting the small area B, but being nearly level (it falls slightly eastward), and unintersected by water-runs, it forms a complete marsh. The northern and southern parts fall considerably towards the Culloch burn on the north and the parish road on the south; the water from the southern slope, west from the summit-point C, is conveyed by the ditches at the roadsides to the river Calder; and east from the same point, the water (with formerly a part of that falling on the central area, and intercepted by the ditch D) is conveyed eastward by the roadside ditches into the feeder at E, which conveys it into the "Black Loch," about three-fourths of a mile eastward. From the eastern extremity of the area A, the moor fell quickly to the former road F, and more gradually to the former ditch G H, from the lowest point of the parish road to the commencement of the burn. This ditch conveyed the water drained from the slope and the low part on both sides of the parish road from E, into the burn at H. This burn runs north-

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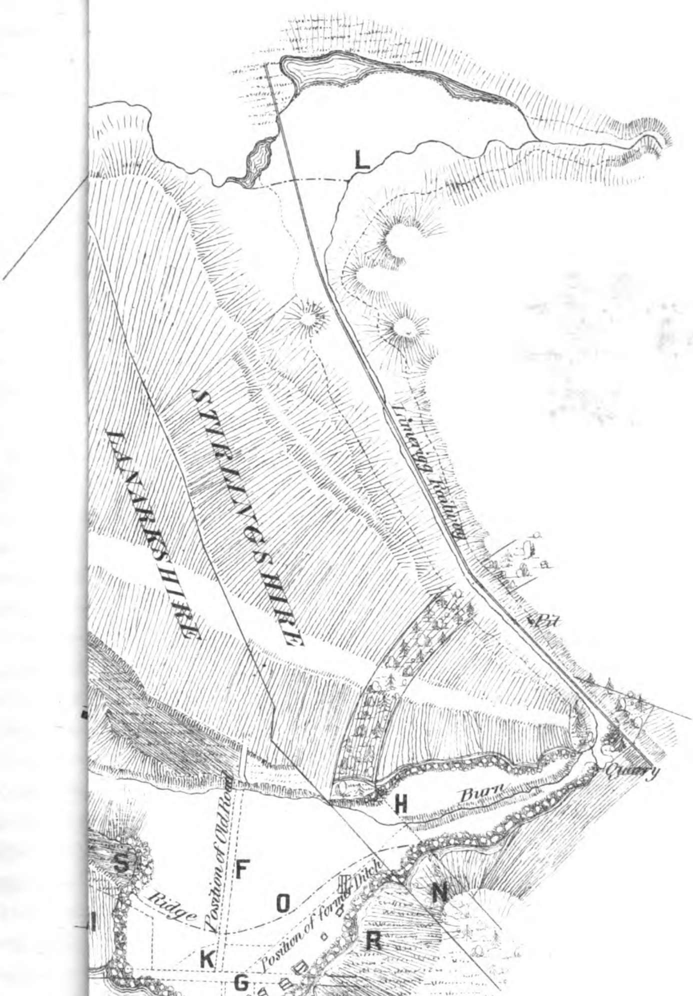
MUGUST 1861, & OF LANDS ADJOINING.



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eastward about 300 yards, when its course changes at an acute angle, and running north-west about 700 yards, it joined the Culloch burn at the point L. The Limerig Colliery railway follows the north-west course of the burn, first on the right bank and crossing to the left, and crossed the Culloch burn westward from the point of junction L. The moor extends a short distance westward from the farm-road to Longrig, but this part has a fall towards the Culloch burn, and is separated from the eastern part by the large water-runs at the sides of the road, conveying the water into the Culloch burn. At the point M, in the eastern extremity of the central area A, there was situated an overgrown pool of water, designated in the district a "blind loch," which for many years has been firm enough to be crossed, though not quite safe, on account of certain wide cracks in its overgrown surface.

The surface of the moor above the road F is said to have been observed to swell during the winter of 1860-61; but on the morning of the 12th August, 1861, after a period of continuous heavy rains, the rain of the previous night having been unparalleled in the district for several years, the surface of the low eastern part of the moss, above and below the road F, burst upwards, giving vent to an immense quantity of water and mud-like peat, which flowed from beneath the surface of the sloping moor above, and carried the torn-up turf before it in a southerly and easterly direction over the parish road, and against the rising ground on the south and east, and the plantation N on the north-east, forming a basin in which the water and fluid peat accumulated; while the surface at and around the blind loch M, and the slope on the east, fell considerably in level, forming a large hollow. The torrent of water and fluid peat tore away and carried into the basin beneath a great quantity of the turf from the surface in large masses. The principal movement lasted only a very short time; but the heavy rains continuing, the water collected in the depressed part, augmented by a great quantity of that falling on the central area (the ditch D, which formerly carried away a part of this water, forming now a part of the depression), ran in the course formed from the blind loch, carrying with it a great quantity of the turf torn from the surface near the water-course, and accumulated in the lower moor for three days, dammed up by the debris intercepted by the plantation, when the plantation gave way before the pressure, and the water and fluid peat, tearing up the moss in the plantation, rushed in a torrent into the burn course, carrying a large quantity of the masses of turf and the broken trees, and depositing them in a heap, to a considerable width, on both sides of the burn, between the plantation and the railway. The fluid peat continued to flow in the course of the burn,

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covering the railway, and spreading to a considerable width over the land on each side, and carrying with it, and depositing on the banks, many masses of turf. It covers a great area at the junction with the Culloch burn, where a large quantity of turf masses is deposited. Below this the peat flowed in the course of the Culloch burn into the river Avon, at Slamannan, its level in the burn's course being generally about 6 feet above the usual surface, though, where sharp bends occur between high banks, its height has been sometimes not less than 12 feet.

At the end of a week after the first outburst the burn had fallen to its usual height in rainy weather, but still carrying much of the soft peat in suspension, and rolling occasional masses of turf. The moss, for about 800 yards west from the position of the road F, had fallen into a great hollow, 250 yards wide and 23 feet deep at its widest and nearly its deepest part, the position of the blind loch M. Below this point the water has exposed the clay substratum on which the moss rested, showing the total thickness of 27 feet of peat, brown and fibrous on the surface, the fibres becoming less apparent as the depth increases, until, about 12 or 13 feet from the surface, they almost entirely disappear, the peat deeper than this being black and pulpy. The underlying clay is a tenacious light-blue clay, evidently of the "boulder clay" formation, as it contains fragments of hornblende, chlorite and mica slates, quartz, porphyries, and various kinds of trap, which must have been brought from a considerable distance, together with fragments of "carboniferous" strata, in great part belonging to the district. The stream (formed since the first movement) runs on the clay for some distance; but at the road F the peat is a considerable depth below the bottom of the water, which is 14 feet below the level of the road where broken off.

The turf on the surface of the depression is cracked and torn asunder, the general direction of the fissures being parallel to the outer edge of the depression. Those at the outer edge are very narrow; but nearer the centre they are from 10 to 40 feet wide; and near the stream and blind loch there appear only masses of turf, imbedded in soft peat, and lying on the clay substratum, or floating on the surface of the fluid peat. The position of the former blind loch appears as a small pool of fluid peat, dammed back by some masses of turf, over which the water falls 4 feet to the clay bottom of the stream. The western and southern sides of the hollow slope regularly to the position of the blind loch and the water-course; but the north side slopes gradually to about 20 yards from the stream, when it falls suddenly in terraces to the water's edge. This step-like fall is, however, the whole width on the north side,

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for about 100 yards above the road F, the stream running here about 10 yards from the edge of the break.

The heap of debris in the lower part extends from the stream on the north, and covers the parish road for a distance of 240 yards, and about an acre of arable land on its south side. It extends 50 yards east from the former ditch G H, and 120 yards west from the former road F. Below the plantation N it spreads on both sides of the burn to the width of 100 yards, and 50 yards at the lower plantation, at the angle of the burn. Above the lowest point G, on the parish road, its height is about 10 feet, its greatest height being along the ridge-line O, where, at the former ditch, its height is about 15 feet above the former surface. On the south side of this ridge-line the heap is principally composed of masses of turf, and on its north side of pulpy black peat, with masses of turf on its surface, sloping to the stream on the north. Below the plantation its height is about 15 feet above the burn, and about 6 feet above the arable land on its banks. At and below the lower plantation the deposit is principally under peat, lying about 2 feet thick on the banks and over the railway, with occasional masses of turf, and about 8 feet above the level of the burn, with a width of only 20 yards at the plantation, the banks being steep, but extending to about 50 yards wide where the burn is again crossed by the plantation N, and 100 yards where it is crossed by the railway. Below this it again contracts to 40 yards, between high banks, before spreading out to the width of 170 yards at the former junction with the Culloch burn, where a great quantity of turf has been deposited in large masses. The Culloch burn has here been caused to leave its former course 100 yards west from the former junction. It now flows round the northern side of the deposit, and enters its former course 200 yards east from the same point. Below this, on the course of the Culloch burn, only occasional masses of turf are to be seen. On the south-west of the debris, and dammed up by it, a large quantity of water lies, covering the road and about an acre of the arable land on its south side. On the south and south-east sides the water has formed a course, running into the burn through the old quarry at the lower plantation; and on the north side a water-course is formed from the plantation N, running into the burn also at the lower plantation.

The height to which the heap of debris rose in the low moor was much higher, before the giving way of the plantation, than the height at which it remained as described; but no definite information could be obtained as to its exact height. The height to which the fluid peat rose in the burn course, below the angle at the railway, was distinctly registered by the deposit of peat left on the banks.

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On the outer edge, on the south-east of the heap of debris, between the points P and R, masses of arable surface appear, evidently from the small arable area K; but no part of the parish road is seen. It would therefore appear that the area of surface torn up extends from the break on the north nearly to the parish road on the south; on the south-east, probably to about the former ditch G H; and on the east, to have disturbed the surface in the plantation N, here growing on moss, which has been torn away on the north side, the solid moss standing 9 feet above the surface of the burn. On the west it was probably bounded by the moss at S, where it is broken off, and seems to have torn up a small part of the arable area I, on the north side of the parish road, as several masses of arable surface appeared on the west side of the debris, with corn, evidently a part of the crop on this area, growing on them. This area would contain about 10 acres.

The broken masses of the road, F, appear on the surface of the debris 135 yards east from its former position, curving round to a point 40 yards from the parish road, on its south side, and about 60 yards south-east from the point where it joined the parish road.

The unusually heavy rains preceding the outburst seem to have overcharged the blind loch, and, either by saturating the under peat, changed it to its present fluid, mud-like state, or finding its way beneath the moss or its surface to the lowest part of the moor, which was fully 50 feet below the level of the surface at the blind loch, the highest part torn away being 35 feet below the same level; and, acting by hydrostatic pressure beneath the surface, overcame its resistance, forcing it upwards, and carrying it before it, in the direction of the slope, to the south and east, heaped the masses of turf against the rising ground and the plantation, and formed a large basin, which was soon filled by the torrent of water and fluid peat from the moor above and the blind loch, and the masses of turf torn from the surface, the accumulated mass at length bursting through the plantation as before described.

This disturbance may be considered of importance geologically, from the permanent alterations it has made in the physical condition of the area over which its effects extended, and as illustrative of the disturbances which have taken place in earlier geological periods—as, for instance, the carboniferous. A new stream has been formed in the centre of the moss, while, in the hollow in which it flows, we have the elements of a large "nip" or "want," considering the moss itself as likely to form in future time a seam of coal. The part of the stream running on clay would form a complete "want," but above and below it would be only partial. The depression also exhibits in every fissure,

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though on a small scale—the moss only being disturbed—the appearances peculiar to slips and faults, running in lines parallel to the central fault. The deposit in the lower moor would also produce a material increase in the thickness, and the deposit on the burn banks, at present covering up a great area of land, mostly arable, might be considered as illustrating the doublings and perplexing appearances of intruding patches of coal in troubled fields. The amount of peat carried away by the river Avon was immense, and forms a feature of importance, in its increasing and modifying the new strata being formed by the silt deposited by that river. We have also new water-courses on both sides of the heap of debris, and the course of the Culloch burn altered, a plantation partially carried away, and a public road and a railway covered up. Some of these alterations will be modified by art, as, in the railway, the moss is already cleared away, and agriculture will modify the deposit on the banks of the burns, incorporating it with the soil. The principal alterations—as the stream from the former position of the blind loch, and the deposit in the lower moor and plantation—will probably, however, remain permanent until modified by nature.

Notes upon Dyeing and Dyed Colours in Ancient Times.

By JAMES NAPIER, F.C.S., &c.

I MAY state at the outset, that, in this inquiry into the art of dyeing in ancient times, I have not been able to find any really intelligible description of dyeing processes, and have therefore had to content myself with the evidence of the existence of colours upon fabrics that must have been dyed, and with collecting the names of the dyeing agents used for that purpose in ancient times, drawing from these a few deductions bearing upon the art: these notes will therefore be somewhat disconnected. To attempt to write anything like a consecutive history of such an art as dyeing in ancient times would be ridiculous; for we find that in all countries and all ages man instinctively seeks to adorn himself in some way, by means of applying colours to his person or dress, so that the fixing of a date or locality for the origin of dyeing is impossible. It is very easy to suppose that the blood of animals and the juice of fruits, such as the grape, staining the skin, would naturally suggest the seeking for and applying a variety of juices, &c., for similar purposes, and thus extend the art. How simple and apparently reasonable is it to suppose that the first person who stained his fingers or his garment with the juice of some plant, at once tried a great many other plants, and then set up a regular dyeing establishment! Yet how contrary to our own

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experience would be such reasoning! We make very few discoveries in our arts by deductive reasoning, although, after a discovery is made, how simple and evident it seems! The account of many discoveries falls upon our ear like a note of condemnation, that a fact so evident and simple should have escaped us; and too often this feeling manifests itself in attempting to detract from the discoverer much of the merit due to him. I believe that such a mode of reasoning, applied to the progress of dyeing in ancient times, would be vain and deceptive. At the same time, the love of distinction, and the application of colours to the person or dress being a ready means of showing this distinction, and the natural emulation to excel in whatever gives distinction, were the stimulants to progress in the dyeing art; and as to the success attained in this art in the time of Pliny—a time, by the way, when dyeing was not so well known as it seems to have been several centuries before—that writer says, after mentioning the luxurious art by which men had surpassed the savour of *natural flowers* by artificial means, "That they had also learned, by dyeing, to emulate the finest colours of these flowers."

I have divided the subject into three heads, *first*, the fabrics or materials dyed; *second*, the colouring matters used; and *third*, the colours dyed. The fabrics that were dyed are of the utmost importance in this inquiry; for the same operations, and often the same dye-drugs, will not produce the same effect upon different kinds of fabric, which will be more fully referred to afterwards. In the meantime I will refer to these fabrics separately.

Skins of Animals.—In all probability the first kind of clothing mankind wore consisted of skins. Scripture says, "Unto Adam also, and to his wife, did the Lord God make coats of skins, and clothed them." Dyed skins were in common use in Egypt from the remotest antiquity; and the Israelites took numbers of them from that country. "Rams' skins dyed red" seem to have been held in high esteem by the Hebrews, and were made the covering of the tent over the ark of the Testimony. It is stated that every man with whom was found rams' skins dyed red offered them, and Moses made a covering for the tent of rams' skins dyed red, and a covering of badgers' skins above that.

C. Hamilton Smith, in Kitto's *Cyclopædia*, says,—"We agree with Dr. Mason Harris, that the skins in question were most likely tanned and coloured crimson, for it is well known that what is now termed red morroco was manufactured in the remotest ages in Lybia, especially about the Tritonian Lake, where the original *ægis* or goatskin breastplate of Jupiter and Minerva was dyed bright

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red; and the Egyptians had most certainly red leather in use, for their antique paintings show harness-makers cutting it into slips for the collars of horses and furniture." And Wilkinson says of ancient Egypt, that they made shoes, sandals, coverings and seats of chairs and sofas, bow cases, and most of the ornamental furniture of chariots, harps, and also shields were adorned with coloured leather, and skins prepared in various ways requiring the dyer's art.

WOOL.—That woollen stuffs were used, and spun and woven into cloth for common use, at a very early period of man's history, is beyond doubt; and that woollen was dyed various colours, either before or after being converted into cloth, is also plainly stated in history, both sacred and profane. It is the opinion of Wilkinson that the ancient Egyptians dyed their woollen stuff in the state of wool or thread, previous to its being woven. The words translated purple, blue, and scarlet, in the Scriptures, refer, in the original, to something more than the colour; it is rather to the coloured material, such as purple or blue cloth or thread. So that such passages as the following: "And this is the offering which ye shall take of them; blue, and purple, and scarlet," embrace the materials dyed in these colours. Although woollens were in common use amongst the ancient Hebrews, it was held in very low estimation with the Egyptians, and was not worn by the better class of society. No woollen was used in wrapping up their dead. The reason for this, as given by Wilkinson, is the tendency of woollen stuffs to breed insects that would destroy the dead body. Others think that this aversion to the use of woollen among the Egyptians arose from its being made from the sheep—an aversion which extended even to the shepherd, as stated by Moses, "Every shepherd is an abomination to the Egyptians." The Hebrew priests were forbidden to wear woollen garments in their official capacity, as a matter of cleanliness. It is said, "They shall be clothed with linen garments; and no wool shall come upon them whiles they minister; they shall not gird themselves with anything that causeth sweat."

SILK.—The existence of silk in ancient times has been doubted by several scholars. Although it is mentioned both by Solomon and Ezekiel, some have endeavoured to prove that the word translated silk in the Proverbs and Ezekiel may with equal propriety be translated fine linen or cotton. In a late article in the Westminster Review it is argued that silk could not have been known in ancient times from its great cost in the early part of our era. Aurelian complained that a pound of silk was sold at Rome for twelve ounces of gold, or weight for weight. But the same argument may be

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used in respect to the Tyrian purple; 1 lb. wool dyed of that colour in the time of Augustus cost upwards of £32 of our money; hence it may be said that Tyrian purple could not be known long before that period. Under the article "Silk," in the *Encyclopædia Metropolitana*, it is distinctly stated that silk was known in very ancient times. Bonomi, in his book on *Assyria*, says, "The custom of presenting robes as a mark of honour may be traced to the remotest antiquity in eastern countries, and even still prevails. The Midian habit was made of silk, and among the elder Greeks it was only another name for a silken robe. The silken robes of Assyria, the produce chiefly of the looms of Babylon, were renowned long after the fall of the Assyrian empire, and retained their hold of the market even to the time of the Roman supremacy." Pliny speaks of the wool of silk, and believed it was washed down from trees, although at a later period the western nations became acquainted with the worm or fly by which the silk is spun. As the worms were bred upon the mulberry trees, the error of washing down the wool from trees was a natural one. Serica, or Seres, the ancient name for silk and for the worm, and also for China, is considered strong evidence that silk was known to the ancients, and that it was imported from the remote countries of the East. A Roman poet, describing the consecration of the pontiff or high priest, says,—

> "For when, with sacred pomp and solemn state,
> Their great high priest the Romans consecrate,
> His silken vest in gabine cincture bound,
> A festal fillet twines his temples round."

Although the precise time that silk was introduced as a fabric for clothing in the more western countries cannot be fixed, still I am strongly of the opinion that the knowledge and use of it extend considerably into ancient times, at least to that of Ezekiel, 594 B.C., who says, "Thus wast thou decked with gold and silver; and thy raiment was of fine linen, and silk, and broidered work."

COTTON.—Cotton was known to the ancients very early, but to what extent it was used in the earlier periods of man's history is not known. Herodotus is the earliest historian who mentions it, calling it a tree wool, observing that the trees of India bear fleeces as their fruit, surpassing those of sheep in beauty, and that the Indians wear clothes made from those trees. Ctesias, a contemporary of Herodotus, and who resided at the Persian court, speaks also of the Indian wool of trees. According to Baines, Yates, and several Biblical commentators, the word translated "green" in Esther i. 6, means "cotton," which shows that this fabric was used in Persia

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at least 100 years before Herodotus wrote; and it is not improbable that Solomon, who traded extensively with India, may have received cotton as part of his merchandise. Dr. Royle tells us, in his *History of the use of Cotton in India*, that its manufactured products, and even the process of starching it, are referred to in the *Institutes of Menu*, at as early a period as 800 years before Christ, close to Solomon's time. Egypt had also a trade with India at a much earlier time than that of Solomon, so that cotton may have been an article of commerce obtained from India as a matter of exchange. The mummy cloths of Egypt have been examined for proof of the use of cotton amongst that ancient people. But, contrary to expectation, all those examined by Bauer, Thomson, and Ure, were found composed of linen. Nevertheless, since these examinations, Dr. Bowring has ascertained that the mummy cloth of a child was formed of cotton, and not of linen, as is the case with adult mummies. Rosselini has found the seeds of the cotton plant in a vessel in the tombs of Egypt, which is an indication that cotton was not only purchased as an article of import, but was cultivated in Egypt. Wilkinson says that cotton cloth was amongst the manufactures of Egypt, and dresses of this material were worn by all classes. Pliny says that the Egyptian priests, though they used linen, were particularly partial to cotton robes; and cotton garments, supplied by the government for the use of the temple, are distinctly mentioned in the *Rosetta Stone*. Bonomi says, "The cotton manufactures were celebrated and remarkable, and are mentioned by Pliny as the invention of Semiramis, who is stated by many writers of antiquity to have founded large weaving establishments along the banks of the Tigris and Euphrates;" and the textile fabrics of Assyria were celebrated all over the civilized world. This implies an extensive shipping trade, and agrees with the words of Isaiah, 800 years before Christ, in reference to Assyria,—"Thus saith the Lord, your Redeemer, the Holy One of Israel; For your sake I have sent to Babylon, and have brought down all their nobles, and the Chaldeans, whose cry is in their ships." From these evidences I think it proven that cotton was not only known, but used, in Egypt, Palestine, and all the other civilized countries in the East, from the earliest times of which we have any record or relic.

LINEN AND FLAX.—Whatever doubts may exist in reference to the common use of cotton and silk in the East, in the early history of these countries, there can be none as to the knowledge and common use of linen. It is familiarly referred to in almost all ancient writings. The Old Testament speaks of linen, fine linen, and fine twined linen, &c.

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These being translations of different words in the original, have given rise to some doubts as to the true meaning of each term, some supposing cotton may be referred to in some of these distinctions; however, the existence of different qualities of linen in ancient times is amply verified, by there existing still a variety of qualities in the wrapping of mummies, and some of a quality which even in the present day we cannot surpass; the quality of one piece found at Memphis "being," says Wilkinson, "to the touch comparable to silk, and not inferior in texture to our finest cambrics." Coloured linens are also extant, of which I will speak hereafter. Linen was common amongst the Hebrews, as every reader of his Bible well knows. In Greece, and all the other nations of antiquity, linen was a common article of clothing; although, from a passage in Professor Ramsay's *Roman Antiquities*, there is an indication that either as a whole or of a certain quality it was scarce and a luxury, "insomuch," says Ramsay, "that the priests of Isis were at once marked out to the eye as a distinct class, by the circumstance of being robed in linen."

I may here state, as my opinion, that all the various fabrics I have named were used less or more from very early times, some from the most remote antiquity, others from at least 700 to 1,000 years before the Christian era. That they were all subject to dyeing processes cannot be affirmed, but only considered a probability. As these different fabrics take the dye differently, often requiring not only different treatment, but different dyeing agents to produce the same effects, our ability to prove the fact that one of these kinds of fabrics was dyed will be no evidence that the others were also dyed. Speaking from modern experience, a dyer may excel in dyeing woollen, and be altogether unable to dye linen. Or, again, a dyeing agent may produce a beautiful red or crimson on woollen, and be quite unfit to give any dye upon linen; and these circumstances may be reversed, so that different treatment, and in many instances different dye-drugs, have to be used for animal and vegetable fabrics, so that in this inquiry these peculiarities will have to be borne in mind, as the ancients, as well as the moderns, would have to contend with these different properties. These we will be able to consider better after briefly noticing the different dyeing agents which, so far as we know, they had to dye with. The following is the list:—

Colouring Matters.—Kermes, indigo and woad, madder, archil, safflower, alkanet, henna, broom, galls, berries, walnut, pomegranate seeds, Egyptian acacia, and shell-fish.

Salts.—Sulphate of iron (copperas), sulphate of copper (bluestone), acetate of copper (verdigris), acetate of iron (iron liquor), alum, alkaline carbonates, lime, and soap.

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A modern dyer confined to this list would be in great difficulties to produce to satisfaction all the colours the ancients possessed, but it would be wrong to conclude that the ancients had not the ability to dye excellent colours. Unfortunately our information about the application of these agents, and even about the agents themselves, is very meagre. The principal source of information is from general historians, the learned men of that day. Now, such arts as dyeing were held in very low estimation by the men to whom we are indebted for the information. If in our day a writer on general history were to include information on dyeing and dye-drugs, and who would not be above using every means to obtain correct information, would nevertheless make but a very sorry and incorrect treatise on that head, what can be expected from writers too proud to condescend to visit workshops or tradesmen, to inquire into their processes? Pliny, on whom we most depend, evidently had this mistaken pride. He says,—"I should have described the art of dyeing had it been included among the number of the liberal arts." It is therefore not too much to suppose that Pliny contented himself with the floating knowledge wafted to him by popular report, which in reference to all arts is full of fallacies. Besides, Pliny lived at a time when the art of dyeing is considered to have been much behind what it had been centuries before, which opinion may be drawn from his own statements. He says the "Greeks, about the time of Alexander the Great, first began to render black, dark blue, yellow, and green dyes, &c., more beautiful, and to learn the art of fixing them on linen. The ancient authors frequently speak of the colours by which the four different parties or factions at the Circensian games were distinguished from each other, and which, on that account, were called the '*colores circenses;*' these were green, aurora, ash colour, and white." In Pliny's own time, or at all events of his own knowledge, he speaks of indigo only as a pigment got from the sea; hence it has been inferred by some writers that indigo was not known as a dye previous to his time. It may be that the Greeks and Romans in his time could not dye with indigo, but there is blue-dyed cloth still in existence, dyed with indigo upwards of 1,000 years before Pliny was born. It is possible that this is one more proof of what I referred to in a former paper upon another art, of an art being known at one time and lost, and again re-discovered, or well known to one nation and not to another. I am inclined, however, to think, that the art of dyeing with indigo was known to practical men in the days of Pliny, although not known to the historian; hence it is erroneous to reason from the silence, or shall I say the ignorance, of such men on the true condition of certain manufactures. It is known that these

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arts were confined to certain classes of the community, who kept their operations secret, so that much was known and practised by them that such men as Pliny could not possibly know. It is stated by Bischoff, "That in every province, and particularly in Phœnicia, there were certain houses for dyeing purple belonging to the emperors, and each of these was under the inspection of an overseer, whose chief business was to take care that the articles were well dyed. These overseers and their work were again under the inspection of a higher functionary." Probably it was one such general overseer that the King of Tyre sent to Solomon,—"A man cunning to work in gold and in silver, and in brass and in iron, and in purple, and crimson, and blue." Neither the dyers nor their children durst follow any other occupation, but formed a peculiar tribe, and had their own symbol, which was a small basket containing purple and wool.

Indigo and Woad.—The indigo-producing plants have been certainly known from the remotest antiquity, which is confirmed by a variety of circumstances, and particularly by its name, *nil*, a name given to it by the Hindoos, which, according to Sir William Jones, means blue. The same name was given it by the Arabs, Egyptians, and other nations of the East, which is a proof that it was first imported from India. At the same time the knowledge of the properties of indigo is indicated amongst nations who had no intercourse with India, and who obtained their indigo from native plants. Cæsar states that the ancient Britons made their blue with indigo from the woad plant, and that their wives and daughters dyed their bodies with it when they appeared naked at the sacred festivals, so as to resemble the Ethiopians. Pliny conceived indigo to be a slime naturally collected in the scum of the sea, and adhering to certain reeds growing on its shores; which Beckman says was the indigo plant stripped of its bark. The peculiar smell which indigo gives when burning, Pliny considered as confirmatory of its marine origin. When the indigo dye or plant was first introduced into Egypt, Palestine, and these localities, is not known; but sufficient for our present purpose is the fact that indigo was known and used by dyers in ancient times for dyeing blues; and that it was used to a great extent is indicated by the cultivation of the indigo plant in those countries, which is believed to have been done in very early times; and it is still cultivated in small quantities. Dr. Bowring says it grows wild in certain parts of Palestine. Volney says it grows with cultivation on Jordan's banks. Burckhardt states that indigo is a common product of the eastern coast of the Dead Sea, and excels that grown in Egypt; and dyeing blue with indigo is still a common occupation of the people of Safet.

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Kermes.—These are the dried bodies of insects which feed upon the leaves of the prickly oak. The word kermés is considered Arabic, and signifies a little worm. This substance has been known as a dyeing agent in the East since before the days of Moses, and was used from time immemorial in India for dyeing silk and woollen, and was also used as a dye-drug by both Greek and Roman dyers. I take the following observations upon the use of kermes in ancient times from Professor Tychsen, as given in Beckman. *Tola* was the ancient Phœnician name for kermes, used both by the Hebrews and the Assyrians; and the Assyrian translators of Scripture use that name in Isaiah i. 18, called in our translation scarlet. The dye was known to the Egyptians in the time of Moses, and the Israelites must have carried it along with them from Egypt. The same writer thinks that the Arabs received the name kermes from Armenia and Persia, where it was indigenous, and long known, and that that name banished the old name, *tola*, in the East, as the name scarlet did in the West. The following is Pliny's account of kermes:—" There grew upon the oak in Africa, Sicily, &c., a small excrescence like a bud, termed *cusculium;* the Spaniards paid with these grains half of their tribute to the Romans. Those produced in Sicily were the worst; those from the neighbourhood of Emerita the best, and they were employed for dyeing purple.

Shell-fish.—The discovery of this means of dyeing is very obscure, and mixed up with fable. The common story is, that a young man, walking along the sea-shore with his sweetheart, their little dog caught at a purpura, by which his mouth became coloured with purple, which the young woman observing, expressed a desire to have a dress of the same colour; and the lover, anxious to gratify her desire, examined and found the shell, and so discovered the dye. Others have said the discovery was made by the Phœnician Hercules, who was also a great navigator. He communicated it to the king, who immediately began to wear purple; and from thence purple has become a regal badge. The date of the discovery has been given differently, as 1500 B.C. and 1250 B.C. Now, purple is referred to before the earliest date here given as being common in Egypt and amongst the Israelites; and purple garments were worn by the kings of Midian as early as 1291 B.C.—showing that means of dyeing purple were known previous to the Tyrian purple.

The shell-fish used for dying purple is named by Pliny the *Conchylium, Murex, Purpura,* and *Buccinum.* He says the best purpuræ taken in Asia were those taken in the sea adjoining to Tyre; that the Tyrians, when they caught any of the greater purpuræ, took the fish out of their shells, the better to extract the colouring matter; but that

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they obtained it from the smaller by grinding in mills; that the fishermen endeavoured to take the purple fish alive, and killed it immediately with a blow, because, if allowed to die slowly, it ejected and lost its precious liquor with its life; and that the fish dies speedily if put into fresh water. The method of catching them is this:—The fishermen take a net with wide meshes, into which, as bait, a few mussels are put. As soon as these are immersed in the water they open their shells, which, when the purple fish observe, they thrust in their tongue; but scarcely do the mussels perceive this, when they again shut their shells, and in that manner are caught. When the purpura is caught, the white vein or receptacle of the colour is taken out and laid in salt for three days; after which the matter so extracted and salted is boiled slowly in leaden vessels over a gentle fire, the workmen from time to time skimming off the fleshy impurities. This process lasted ten days; after which the liquor was tried by dipping wool into it; and if the colour produced was defective, the boiling was renewed. Pliny says this liquor was generally used with other dyes, by which a variety of tints were produced. Amongst these other dyes are named the kermes, archil, and alkanet root.

By whatever way the dye was produced, purple colour was certainly in ancient times held in high estimation, and in later times was appropriated to the services of religion, and to distinguish the highest civil and military dignities, and even ultimately became the emblem or symbol of majesty; and the wearing of it, under some of the Roman emperors, by any not of the imperial family, was deemed treason, and punishable by death. It is not to be wondered at that such restrictions would do much to allow the knowledge of producing the colour to die out and be lost. Many attempts have been made in modern times to recover the knowledge of producing this celebrated dye from shell-fish, with various success, but none to warrant its being tried as a manufacture. The history of these trials would itself form a most interesting paper, but does not come within my present purpose. We have murexide as a dye got from guano, and which the late Dr. George Wilson considered to be the same as the ancient purple; but in practice it does not give either the permanency or beauty history ascribes to the Tyrian purple, probably from want of the proper mode of application. Our mauves, or purples from coal tar, however, will stand favourable comparison with any purple ever produced either in ancient or modern times. I take the following from Johnson's *Introduction to Conchology* as embracing most of what is known of modern effort to produce the dye. I have myself got a beautiful permanent purple from the purpura lapillus, found in Arran.

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Several shell-fish have the power of secreting and throwing out a fluid when irritated. Some of these fluids are purple-coloured; they have been occasionally collected and tested, and several eminent men have considered that this fluid, so excreted, may have formed a part or whole of the celebrated purple dye of ancient times. With this view Johnson disagrees. As these excretions are from the first a purple colour, and liable to change by acids and alkalis, and fade by exposure, he thinks they formed no part of the Tyrian dye, for unchangeableness was one of its characters; and Aristotle and Pliny state expressly that the colour of that fluid, on its first discharge from the animal, was white. Such a coloured liquid can be procured, as these authors say it was procured, from several univalves belonging to the genera murex and purpura. And Colonel Montagu furnishes us with a good account of it in the purpura lapillus,—"The part containing the colouring matter is a slender longitudinal vein, just under the skin on the back, behind the head, appearing whiter than the rest of the animal. The fluid itself is of the colour and consistence of thick cream. As soon as it is exposed to the air it becomes of a bright yellow, speedily turns to a pale green, and continues to change imperceptibly until it assumes a bluish cast, and then a purplish red. Without the influence of the solar rays it will go through all these changes in two or three hours; but the process is much accelerated by exposure to the sun. A portion of the fluid, mixed with dilute vitriolic acid, did not at first appear to have been sensibly affected; but by more intimately mixing it in the sun, it became of a pale purple, or purplish red, without any of the intermediate changes. Several marks were now made on fine calico, in order to try if it was possible to discharge the colour by such chemical means as were at hand; and it was found that, after the colour was fixed at its last natural change, nitrous no more than vitriolic acid had any other effect than that of rather brightening it. Aqua regia, with or without solution of tin, and marine acid, produced no change, nor had fixed or volatile alkali any effect. It does not in the least give out its colour to alcohol, like cochineal, and the succus of the animal at Turbo (scalaria) clathrus, but it communicates its very disagreeable odour to it most copiously, so that opening the bottle has been more powerful in its effects upon the olefactory nerves than the effluvia of assafœtida, to which it may be compared. All the markings which had been alkalized and acidulated, together with those to which nothing had been applied, became, after washing in soap and water, of a uniform colour, rather brighter than before, and were fixed at a fine unchangeable crimson."

Madder.—This important colouring matter was known to the

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ancients as a dye-drug. Pliny says expressly that the red roots of the *rubia* were used to dye wool and leather red. It is also stated by Beckman, quoting Dioscorides, that the thin long roots, &c., which are red, serve for dyeing; and on that account the cultivated kind (which indicates an acquaintance with a wild sort) is reared with much benefit in Galilee, around Ravenna in Italy, and in Caria, where it is planted either among the olive trees or in fields destined for that purpose. Virgil refers to the madder plant, and says the sheep feeding upon it had their wool coloured red. It is known that swine and several other animals have their bones coloured red by eating madder. Dr. Kitto, in his *Physical History of Palestine*, says madder grows abundantly in Syria and Palestine. The dye from the madder root was certainly in very common use among the Egyptians, and doubtless also among the Hebrews. The reddish-coloured dye of the mummy cloths appears to have been produced from madder, and remains a curious and interesting monument of its use.

CARTHAMUS, or safflower, was cultivated in Egypt in very remote times, where it is still cultivated, producing the best quality of the dye. Wilkinson says it is now proved by the discovery of the seeds of *Carthamus tinctorius* in a tomb in Thebes that the plant was cultivated in ancient Egypt, not only for the dye it produced, but for an oil extracted from its seeds.

ARCHIL.—Theophrastus and several other ancient writers refer to a plant that grew upon the rocks of different islands, particularly in Crete or Candia, and which had been used for a long time as a dye for wool, which it dyed violet, and excelled the ancient purple. This plant Beckman and several others consider to have been the lichen *Roccella*, our archil. Pliny says that with this lichen dyers gave the ground or first tint to those cloths they intended to dye with the costly purple. I think it very probable that this method of bottoming the purple with archil was only introduced at a later date, probably after the true purple dye became scarce and costly.

HENNA.—This plant, which is abundant in Egypt, Arabia, and Palestine, was used by the ancients as well as moderns for dyeing. The leaves of the plant were dried and pulverized, and then made into a paste. It is a powerful astringent dye, and is applied to desiccate and dye the palms of the hands and soles of the feet and nails of both, and gives a sort of dun or rust colour to animal tissues, which is very permanent. It is stated that when sal-ammoniac and lime were put upon the coloured parts they changed to a dark greenish-blue colour, and passed on to black, probably from the sal-ammoniac containing iron, which would give this result. The

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Tyrian ladies dyed rings and stars upon their persons. Men gave a black dye to the hair of their heads and beards. The dyeing of the nails with henna is a very ancient custom. Some of the old Egyptian mummies are so dyed. It is supposed that the Jewish women also followed this custom.

Galls are named amongst the substances known to the ancients in the arts, but I cannot find whether they were used as a dyeing agent. Wilkinson says that tanning was in Egypt a subdivision of dyeing, and it is mentioned that copperas with galls dyed leather black; and there is little doubt but galls were used for a similar purpose in ordinary dyeing. The *Myrobollans* and several sorts of bark and pods of the *Acacia nilotica* were also used for tanning, from their astringent properties, and may have been similarly used for dyeing.

These are a few of the principal colouring matters used by dyers in ancient times. As to some of the salts named as having been used by them, there is a little confusion, especially the alkaline salts—a circumstance, however, not to be wondered at. In more modern times there is a similar confusion on this same head. Nitre, for instance, when burned with carbonaceous matters produces carbonate of potash; the burned ashes of wood produce the same salt; burned ashes of seaweed produce carbonate of soda, nitre with sulphur, sulphates, &c. Now, these have all been called nitre, with a certain affix well understood by the adept or chemist of the day. Did your time allow, I could show that probably all these operations, and many more in reference to the alkalis, were practised; but now, having only the generic name, nitre, given us, we cannot understand exactly which of the nitres are meant. When Solomon speaks of the action of vinegar upon nitre, the chemist understands what salt is referred to; but where the nature of the action or application is not given, we have no idea what particular salt is meant; but there is no doubt the ancients were well acquainted with the alkaline salts of potash and soda, and applied them in the arts. The metallic salts of iron, copper, and alumina are much more distinctly understood, and their application to dyeing was generally the same as at the present day; and that they were used both as mordants and alterants is evident from several references. A very suggestive statement is made by Pliny about the ancient Egyptians. "They began," says he, "by painting or drawing on white cloths with certain drugs, which in themselves possessed no colour, but had the property of attracting or absorbing colouring matters; after which these cloths were immersed in a heated dyeing liquor; and although they were colourless before, and although this dyeing liquor was of one equable and uniform colour, yet when taken

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out of it soon afterwards, the cloth was found to be wonderfully tinged of different colours, according to the peculiar nature of the several drugs which had been applied to their respective parts, and these colours could not be afterwards discharged by washing."

Herodotus states that certain people who lived near the Caspian Sea could, by means of leaves of trees which they bruised and steeped in water, form on cloth the figures of animals, flowers, &c., which were as lasting as the cloth itself. This statement is more suggestive than instructive. Persia was much famed for dyeing at a very early period, and dyeing is still held in great esteem in that country; and notwithstanding their being Mohammedans, they have chosen Christ as their patron; and Bischoff says that they at present call a dye-house Christ's workshop, from a tradition they have that he was of that profession. They have a legend, probably founded upon what Pliny tells of the Egyptian dyers, "That Christ being put apprentice to a dyer, his master desired him to dye some pieces of cloth of different colours; he put them all into a boiler, and when the dyer took them out he was terribly frightened on finding that each had its proper colour."

Different Colours.—Looking over the list of dyes and salts as mordants—the whole of which I think we have not got an account of—the ancients may have had a considerable variety of colours and tints; but, as might have been anticipated, there are very few colours named, owing, no doubt, to a confusion of tints. In Scripture we have only blue, red, crimson, purple, and scarlet; but what distinguished red from crimson or scarlet we do not know, but will take them as translated. Profane history mentions, in addition to these, yellow, green, and black; but they could not fail to have all the intervening tints. It is worthy of remark that in Scripture there is no reference to either yellow or green. The people being so fond of gold ornaments, we would naturally reason that the colour of gold would be a prevailing tint in their dress; but colours, as in most things else in the East, were symbolical. Yellow was a symbol of subjection, and although esteemed, yet, according to Pliny, it was exclusively worn by women; so that if the same idea existed in early times, the Hebrews would avoid it, especially in connection with their religious services. It is stated that the veils that brides wore on their wedding day were entirely of yellow,—a symbol of promise to serve, honour, and obey. The dyeing of the nails yellow, as formerly noticed, may have had a similar meaning. Another reason that may be supposed for the absence of yellow dye in their embroidery for the tabernacle is, that linen dyed yellow by any of the dye-drugs that we know they used was fugitive, passing speedily into a very dirty

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faded tint that would have destroyed the effect of the whole embroidered figure. That this had something to do with it is made probable by the use of gold thread along with the other dyed threads in their embroidered work. "And they did beat the gold into thin plates, and cut it into wires, to work it in the blue, and in the purple, and in the scarlet, and in the fine linen, with cunning work." Wilkinson, speaking of the combination of colours in Egypt, says, that when black was used, yellow was added to harmonize with it. Black is a colour never named amongst the Hebrews as a dye.

Scarlet.—This colour was in the East a symbol of triumph and rejoicing, and is still used as such in India. Scarlet flags are used on the temples, and as personal exhibitions of security and joy. During the feast of the Hooli the inhabitants are in the habit of scattering cinnabar; and on all great Hindoo festivals it is the custom to wear necklaces of scarlet silk or worsted thread, so that in the East a scarlet thread or cord was a thing easily procurable in any house, and ready at hand, as we find it on the first mention of that colour in Scripture, several years before the family of Jacob went into Egypt. Indeed, it is the first dye mentioned in history, and although only incidentally, yet in such a common and familiar way that shows the colour was well known. And again, on another interesting occasion, a scarlet cord is easily procured by Rahab; and in this instance it is not without its symbolical meaning, as a token or covenant of security. In some of the Hebrew rites, such as the ceremony of pronouncing a person or house free of leprosy, scarlet is used along with hyssop, which is no doubt as a symbolical expression of joy and triumph; and the spreading of a scarlet cloth over the ark of the covenant during its movement from place to place may also be a symbolical expression of security. It is also mentioned as the dress of females in David's lament for Saul, and probably in its symbolic sense,—

> "Ye daughters of Israel, weep over Saul,
> Who clothed you in scarlet and delightful garments,
> Who put on ornaments of gold upon your apparel."

In Babylon Daniel is said to have been clothed in scarlet by the king; but in this case it is considered that purple is meant.

Whether the term translated scarlet referred to the same tint as we designate by that name it is impossible to tell; but from the fact already stated, that it refers to kermes, it is evident that if not that fiery red we call scarlet, it was a bright rich red quite distinct

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from crimson and purple. We have no evidence as to which fabric the colour is at all times referred to, but if on linen or cotton, and dyed by kermes, then it is one of the lost arts: however, they might have a red from safflower upon linen; but this is a fugitive dye. They might also have a red colour with madder; but neither of these gives the tint of kermes. It is more than probable that scarlet was generally upon worsted; but even upon that fabric we could not dye a very good or permanent colour with kermes without a tin mordant. It is possible they had tin dissolved as a mordant: it is the opinion of some that they must have had; but there is no evidence to prove it; but whatever was the mordant used, the dye appears to have been fast. We have a beautiful figure drawn from its permanence by the prophet Isaiah—"Though your sins be as scarlet, they shall be as white as snow; though they be red like crimson, they shall be as wool." Had the prophet been content with the extreme opposite of purity, he would have named black; but this colour is not permanent, and is easily removed, and on this account would not have suited the lesson meant to be conveyed. This was not the case with scarlet. The word translated crimson here is universally admitted by scholars to be wrong, and should be translated "double scarlet," or "scarlet double dyed;" and the passage should read—"Though your sins be as scarlet, they shall be as white as snow; though they be red as scarlet double dyed, they shall be as wool." Scarlet is referred to by Nahum, who wrote nearly 800 years before Christ, as the dress of soldiers,—

> "The shield of his mighty men is made red;
> The valiant men are in scarlet;"

no doubt here as a symbol of triumph.

Red.—The word red is referred to in Scripture repeatedly in connection with scarlet—red as scarlet, &c.; but as a distinct tint or dye it is only mentioned in Scripture in reference to rams' skins, which were used as coverings for the furniture of the tabernacle. Some commentators think this referred to the skins of a certain kind of sheep, having wool of a reddish-brown or fawn colour much esteemed in the East; but in all the passages it is distinctly stated rams' skins *dyed* red, except in one place, where it is red skins of rams, so that I think we are not warranted in supposing they were natural, but were dyed in the tanning. Coloured leather, as before-mentioned, was common in Egypt long before the exodus, as noticed by Wilkinson. Red, in Egypt, was used as emblematic of the earth or earthy.

Crimson.—This is another colour which is very seldom referred to

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as a particular dye. It occurs as one of the three colours of the vail in Solomon's Temple, thus,—"And he made the vail of blue, and purple, and crimson, and fine linen, and wrought cherubims thereon." It is stated, in reference to Hiram, that he was cunning to work in purple, and crimson, and blue, evidently meaning the knowledge of the combination of the whole range of colours used in embroidery. Crimson is once mentioned by Jeremiah: here, however, it is universally agreed, it should be translated scarlet, and the language bears out this, as it evidently refers to the symbolical meaning of scarlet, thus,—"And when thou art spoiled, what wilt thou do? Though thou clothest thyself with crimson (scarlet), thy lovers will despise thee; they will seek thy life."

BLUE.—This colour as a dye is referred to very early, and, as may naturally be expected, had a high symbolical application. Blue being the colour of the skies—the seat of the gods—became a colour emblematic of heaven, although it soon begat a superstitious belief. There is a beautiful poetic illustration of this symbolical meaning in a picture found in a mummy-case a short time ago. The blue vault of heaven is represented by the goddess Neith; beneath this is the deceased with two bodies; his earthy body is red, and is in the act of falling to the ground, whilst his spiritual or heavenly body is blue, and stands upright, raising his hands to heaven. In this way was expressed in a picture their belief in the immortality of the soul. In the East, blue was the colour of protection, and continues so till the present day. It may have been in connection with this heavenly emblem that the cloth covering of the tabernacle was of blue. In the East, says Mrs. Postans, they wear blue as a protection against an evil eye. "I inquired," says she, "why the favourite mares of the Balooche chiefs had necklaces of blue beads, and was told it was to protect them from an evil eye. My water-drawer always saw that the one blue ball was securely tied round the throat of his little bullock; and a Hummall in my service in India, who had been a sufferer from a stroke of the land-wind, at once tied a blue cotton thread round his ankle, on which, he said, the evil spirit that tormented him would be obliged to fly. The torquoise stone is often worn, in consequence of its colour, as a protection of the wearer against disease and evil eye." May not some of these ideas and superstitions have their origin in higher sentiments? Moses is commanded to direct the children of Israel to put upon the fringe of the borders of their garments a ribbon of blue, as a memorial that when they looked upon it to remember their God and all his commandments. And in the transit of the tabernacle furniture, during their march in the wilderness, all the sacred things, as ark, candlestick,

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&c., were all covered with a cloth of blue. The curtains of the tabernacle were attached to each other by loops of blue, fifty loops to each curtain. The breastplate was bound to the girdle by a lace of blue. The plate of gold, whereon was written "HOLINESS TO THE LORD," was tied by a lace of blue to the front of the mitre. The robe of the ephod worn by the high priest was all of blue. Indeed, this colour seems to have been what may be termed the covenant colour of the Hebrews, to put them in remembrance of God, and faith in his protection. The blue, purple, and scarlet, combined in their embroidered work upon the fine linen in connection with the tabernacle, may have had its symbolic meaning,—purple, regality; blue, protection; scarlet, triumph; and white linen, purity. A combination of the same colours formed the vail of Solomon's temple. In Babylon blue seems to have been a favourite colour worn by the highest classes, whether from any superstitious idea of it in relation to protection is not stated. Ezekiel says, "She doated on her lovers, on the Assyrians her neighbours, who were clothed with blue, captains and rulers." He again says of the Assyrians, "That they exceeded in dyed attire upon their heads, after the manner of the Babylonians of Chaldea, the land of their nativity." Loftus tells us, in his *Researches in Ancient Chaldea*, that in ancient burying-grounds the skeleton is found holding cylinders of agate with a copper bowl, and that the corpses have been dressed with blue linen.

These facts show the prominence and common use of blue dye in ancient times; and there is little doubt but the dye was indigo, not only from the fact that indigo was in possession of the ancients, but that blue linen still extant is found to have been dyed with indigo. Whether they dissolved their indigo by the same means we do, is not known; but they had the same re-agents to do so, both for dyeing animal and vegetable fabrics. And although the Greeks at the time of Pliny may not have known the use of indigo as a dye, still there is no doubt but that other localities produced the dye from indigo at that time, as well as for nearly two thousand years before. That certain localities were more famed for, and the inhabitants devoted themselves to, particular branches of trade is indicated clearly by Ezekiel, who gives a list of these localities and trades, and in reference to dyed colours, he says,—

> "Fine linen, with broidered work from Egypt,
> Was that which thou spreadest forth to be thy sail;
> Blue and purple from the Isles of Elisha
> Was that which covered thee."

It is stated that Hoan-ti, one of the earliest emperors of China, was the first who wore a blue dress, as being the colour of the heavens, and a

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yellow one, as being the colour of the earth; he also caused dresses of different colours to be made, in imitation of flowers and birds, that they might serve as marks of distinction to the high and the low, the rich and the poor, in his empire.

PURPLE.—According to popular belief this is the colour *par excellence* of the ancients, and has given the art of dyeing a position in ancient history which it would not have had else. The Tyrian purple is described as surpassing in brilliancy every other dye, although I have no doubt that some of our coal-tar colours are much more beautiful. Purple, like the other colours, had an emblematic significance. Whether it had any religious meaning I have not been able to ascertain; but it became an emblem or badge of royalty or royal favour towards the Christian period, particularly in Rome, where the distinction became a legal enactment. I think commentators and some other writers have misapplied this circumstance by referring it to all ancient times and all nations; and have identified all purple colours with the Tyrian purple, or that dyed by shell-fish. Now, both the Egyptians and Hebrews, and I believe other nations, had purple cloth and thread long before even the earliest date ascribed to the discovery of the Tyrian dye, which is said to have led to its adoption as a colour for kings. In Egypt, Pharaoh, who made Joseph next to himself in dignity, took off his ring from his hand, and put it upon Joseph's hand, and arrayed him in vestures of fine linen, and made him ruler over all the land of Egypt. Had purple marked royal favour in Egypt at this date it would have been named. In fitting up the tabernacle, where a leading feature was to impress on the Hebrews to look on God as an earthly as well as heavenly king, purple is made less prominent than blue and scarlet, although abundant and previous to the discovery of the Tyrian purple. The only place where purple is named and used apart from the other colours is as follows:—"And they shall take away the ashes from the altar, and spread a purple cloth thereon: and they shall put upon it all the vessels thereof, wherewith they minister about it, even the censers, the fleshhooks, and the shovels, and the basons, all the vessels of the altar." These were afterwards covered with skins, and so carried. It would be difficult to see any special emblem of royalty in this use of the purple cloth. The first indication I find is in the time of Gideon, between two and three hundred years after the erection of the tabernacle, where, amongst the spoils taken from the enemy, are named the purple raiment that was on the kings of Midian. In the furniture of the temple of Solomon purple gets no higher prominence than the other colours used along with it for tapestry and embroidered work. However, Solomon, in his allegorical song, refers to purple as a

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covering for the royal chariot. At the same time the same writer speaks of it as a dress worn by an industrious and frugal wife,—

> "She worketh beautiful vestments for herself;
> Her clothing is fine linen and purple."

That it was held as a mark of high honour in Babylon, in the times of Jeremiah, is evident from their gods being clothed in purple and blue, probably emblematic of power and protection. In Persia, in the time of Esther, between 500 and 600 years before Pliny, Mordecai is ordered to be clothed in royal apparel, which is stated to be blue and white, with a garment of fine linen and purple. It appears to me probable that the adoption of purple robes or garments as a badge of royal distinction was gradual, and limited to certain nations; and not till the palmy days of Rome was it limited to royalty, or distinctive of royal favour, although royalty and the higher classes had their marks of distinction in dress in all ages and nations, and purple may have formed a part, but only a part, of such dresses. It is well known that dresses of divers colours have been marks of distinction from the earliest periods, and are still so in the East. Jacob gave Joseph a coat of many colours, the symbol of which his brethren well understood, and it increased their enmity. Some suppose this coat was like our tartan, others that it was made of patches of different coloured cloth. Roberts, in his *Illustrations of the East*, says,—"For beautiful and favourite children, crimson and purple and other colours are tastefully sewed together. Sometimes children of Mohammedans have their jackets embroidered with gold and silk of various colours; a child being clothed in a garment of many colours, it is believed that neither tongues nor evil spirits will injure him." In Persia, India, and China, vestures composed of various colours are still worn as marks of distinction; but embroidered garments of various colours have been emblems of the highest distinction, even of royalty, from the most ancient times. Such was the distinctive badge of the furniture of the tabernacle, and such was the highest mark of honour an ambitious and loving mother is represented as seeking for her son,—

> "Have they not sped? have they not divided the spoil;
> To Sisera a spoil of divers colours,
> A spoil of divers colours of needlework,
> Of divers colours of needlework on both sides,
> Meet for the necks of those who take the spoil?"

Homer indicates this embroidered work as a dress of kings, thus,—

> "The bitter weapon plunged into his belt,
> Transpierced the 'broidered cincture through its folds,
> His gorgeous corselet," &c.

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In David's time garments of divers colours were worn by the king's daughters before they were married. Pliny refers to embroidered and also woven cloths of different colours being known to Homer, and that the Babylonians were the most noted for their skill in this kind of work. It was no doubt one of these wrought and coloured garments that tempted Achan to break Joshua's order. In his confession he says —"When I saw among the spoils a goodly Babylonish garment, &c., I coveted them, and took them."

The Egyptians also were skilled in this sort of work. Wilkinson says,—"Many of the Egyptian stuffs presented various patterns worked in colours by the loom, independent of those produced by the dyeing and printing process, and so richly composed that Martial says that they vied with the Babylonian cloths embroidered with the needle. The weaving of patterns of different colours into cloth is very suggestive of high attainments in that art." From these and many other references, which your time forbids repeating, I am of opinion that although the purple colour was symbolical of power and authority, it was not worn alone in the more early times, but combined with other colours. Neither was the colour itself exclusively worn by people in power or authority, but worn in many ways, and put to various uses, by those who could afford it. That produced from shell-fish seems to have been a costly dye, which made it more exclusive. The sails of vessels, in the earliest times, were made of rich colours, with fanciful devices embroidered upon them, some representing the soul of the king, flowers, and other patterns; while others were adorned with coloured checks or stripes. Embroidered sails were long a manufacture of Egypt, and seem to have been bought by the Tyrians for that purpose, as stated by Ezekiel,— "Fine linen, with embroidered work from Egypt, was that which thou spreadest forth to be thy sails." This sort of sails, Wilkinson says, is very ancient in Egypt; and the hem or border of the sails was neatly coloured. The use of these sails was mostly confined to the pleasure boats of the grandees and of the king, ordinary sails being white. It is stated that the devices and colours on these sails were signs of the condition of the party. Such a custom as this, no doubt, gradually brought into use certain colours, or combination of colours, as marking distinctions of rank; and as wealth always imitated greatness or power, an exclusive right would come to be enforced by kings in favour of, or as a protection of, their symbol. It is mentioned by Atticus that the sails of the large ship of Ptolemy Philopater were of fine linen, ornamented with a purple border. Upwards of a century after this Julius Cæsar prohibits the use of purple to his subjects, except upon certain days. After this time we find the ship of Antony and Cleopatra, at the battle of Actium, distinguished from the rest of the fleet by hav-

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ing purple sails,—a distinction which is said to have been at that time the peculiar privilege of the admiral's vessel; and in the time of Nero the wearing of purple without his authority was punished with death, —restrictive laws which, I think, indicate that previously the use of the colour was common, although that particular sort of it known as Tyrian purple may have been necessarily confined to the wealthy, from its very great cost. As to its cost and durability, it is related that Alexander the Great found in the treasury of the Persian monarch 5,000 quintals of Hermione purple of great beauty, and 180 years old, and that it was worth £25 per lb. of our money. Pliny states that in the time of Augustus 1 lb. wool dyed Tyrian purple cost about £32 of our money. It appears that these remarks refer to some particular tint or quality of colour, which is not at all clearly defined by Pliny. He refers to a sort of purple or hyacinth that was worth, in the time of Julius Cæsar, 100 denarii, about £3 of our money per lb. And again, in describing the dye, he says that 100 lbs. of the liquor of the pelagium or purpura could be purchased at about 50 denarii, or 30s.—the liquor of the buccinum being double that price; and that 50 lbs. of wool required 200 lbs. of the liquor of the buccinum, and 110 lbs. of the purpura, to dye a durable colour like the amethyst. Now this would only be about 3s. per lb. of wool; and this, at the time when it was death to wear the colour, is not easily reconciled. Indeed, so much confusion exists about the statements of this Tyrian purple, that not a few have considered the whole matter of the shell-fish dye a sort of myth; not that there was no truth in the shell-fish producing a dye —that cannot be gainsayed; but that the many wonderful stories told about it in ancient times were made a blind to cover and conceal the knowledge of cochineal and a tin mordant which, it is maintained, the Tyrians possessed. Bruce, in his *Travels*, gives this opinion, and says, that "if the whole city of Tyre had applied themselves to nothing but fishing, they could not have dyed twenty yards of cloth in a year." And certainly, from the mode of fishing which Pliny gives, by mussels in a net, and from the small intensity of the colour indicated by the quantity required, 3 lbs. of liquor to dye 1 lb. of wool, is very unfavourable to large trade. If, according to our modern researches into this dye, one fish, the common purpura lapillus, will only produce about one drop of the liquor, then, from the above data, it would take about 10,000 fish to dye 1 lb. of wool; so that only 3s. for this is out of the question, or even £32 is not extravagant. I think the error lies in confounding all purple colour with the Tyrian or shell-fish colour, which seems to have been rare and costly at all times, and necessarily so. And although different means of dyeing a purple were practised, such were naturally kept secret—at least, Pliny does not seem to have

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known them. The process for dyeing with the shell-fish, according to Pliny, seems to have been simple. The liquor, after being boiled and prepared, as already described, had the cloth merely dipped into it. The Jews are said to have immersed their wool in lime-water before it was dyed, and then washed it in a ley.

"The Greeks, according to a certain Democritus, poured the liquor as it came from the fire into a vessel, immersed the wool in it, and suffered it to remain in that a day and a night."

The Romans suffered the wool to remain in the liquor five hours, after which they dried it; they then immersed it in the liquor again, and continued in this manner till it had imbibed all the dye.

Pliny says the liquor of the buccinum alone gave a false dye; it was therefore necessary to fix it by the liquor purpura, in order to render it durable.

The Tyrians gave the first ground of their purple dye by the unprepared liquor of the purpura, and then improved or heightened it by the buccinum. In this manner they prepared their double-dyed purple, called *purpura debapha*, which was so called either because it was immersed in two liquors or because it was first dyed in the wool and then in the yarn.

As to black colour, this has always been the symbol of affliction, disaster, and privation; and the colour is studiously avoided by the orientals. It is never referred to in the Scripture as a dye. A black dress was sometimes imposed as a mark of humiliation, by dominant parties, upon those under them. The Jews in Turkey are still obliged to wear black turbans.

Green is a colour not referred to in Scripture as a dye, and very seldom in any other writings, and does not seem to have been much worn in ancient times, probably from the difficulty of dyeing a good green, requiring two distinct dyes—a blue on yellow, or *vice versa.* It is the colour ascribed to Venus by the Sabeans, whose astrologers ascribed seven colours to the different planets,—Saturn, black; Jupiter, orange; Mars, red; Sun, yellow; Venus, green; Mercury, blue; Moon, white.

The PRESIDENT, in the course of the conversation which followed the reading of this paper, remarked that Mr. Napier was probably correct in ascribing the loss of some of the ancient arts to the policy of their inventors in keeping them secret. The knowledge of such concealed arts would necessarily die with the inventors. Nor was it unlikely that many of the inventions of modern times would share the same fate if certain parties should succeed in their desire to obtain the abolition of the patent laws.

The President then declared the Session of the Society to be closed.

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NOTE REFERRED TO IN PAGE 167.

My learned friend, Dr. Scouler, having seen the preceding paper as it was passing through the press, has kindly furnished me with a note of the opinions of Aristotle on the right and left sides of the body, which, as it was new to me, and may be so to other members of our Philosophical Society, I here subjoin. Dr. Scouler remarks that the explanation adopted above is partial, applying only to man and animals organized like him; while the law enunciated by the Stagirite, that all motion originates on the right side, is a general law, observed more or less throughout the animal kingdom. Does it not, however, depend universally on a difference in the organization of the two sides, which, though it varies in animals of different type, is always subservient to the predominance of the right side?

ARISTOTLE, DE ANIMALIUM INCESSU.

There are six dimensions by which all animals are limited, viz., the superior and inferior, anterior and posterior, and the right and left. All living beings, both plants and animals, have a superior and inferior extremity. These last are determined, not by position with respect to the earth and sky, but by function; for where the food is taken in, and whence growth proceeds, that is the superior in each being, and that to which it tends is the inferior; for the one is the beginning (ἀρχή), the other is the end; for the beginning is that which is superior, and in plants the beginning appears to be that which is inferior. Superior and inferior have not the same position in plants as in animals; but with respect to function they are the same; for in the one the roots are to be understood as superior, for it is from them food is taken by the plant, as in animals it is taken by the mouth. Such as not only live but are also animals have an anterior and posterior extremity. All animals possess sensation, and this determines what is anterior and posterior; for the seat of the senses is anterior, and its opposite is posterior. In those animals which have not only sensation but locomotion there is a right and a left, which are to be determined, in like manner, by function, and not by position; for the beginning of locomotion is by nature from the right, and the opposite, which follows, is the left. This is more apparent in some than in others. In those which employ organic parts, such as feet or wings, or something analogous, this is very apparent. Those, again, which have not these parts, but move the body by undulation, as apodous animals, the serpent, caterpillars, and earthworms, possess all that we have mentioned, but not so obviously. It is a proof that the right is the beginning of motion, that all throw the burden on the left side; for that which supports the weight must be moved, while that which moves is free. If we leap upon one foot, it is easier to do so on the left than on the right; for it is the nature of the right to move, and of the left to be moved. Wherefore the burden should rest on the part moved, not on the part moving; for if placed on the mover and principle of motion, there will be no motion whatever, or at least it will be difficult. The mode of projection of the feet in walking is a proof that motion originates in the right, for all project the left foot; and when standing, the left is thrown forward, unless some accident prevent; for that which is thrown forward is not the mover, but that which is behind. It is also in this way that the right side is protected. For the same reason the right is the same in all; for according to nature that is the right which is the beginning of motion. Thus all turbinated shells are dextral, as the purpura and buccinum, for they move in a direction opposite to the apex of the shell. As all motion begins from the right, they all move in the same direction, for the right is the same in all. The left hand is freer in man than in other animals, for he is of a higher nature. The right is superior by nature, and more determined; therefore man is especially right-handed.

ERRATUM.—In list of Cumbrae plants, p. 114, one species of Grass has been inadvertently introduced under two names; delete *Ammophila arundinacea*, and retain *Psamma arenaria.*

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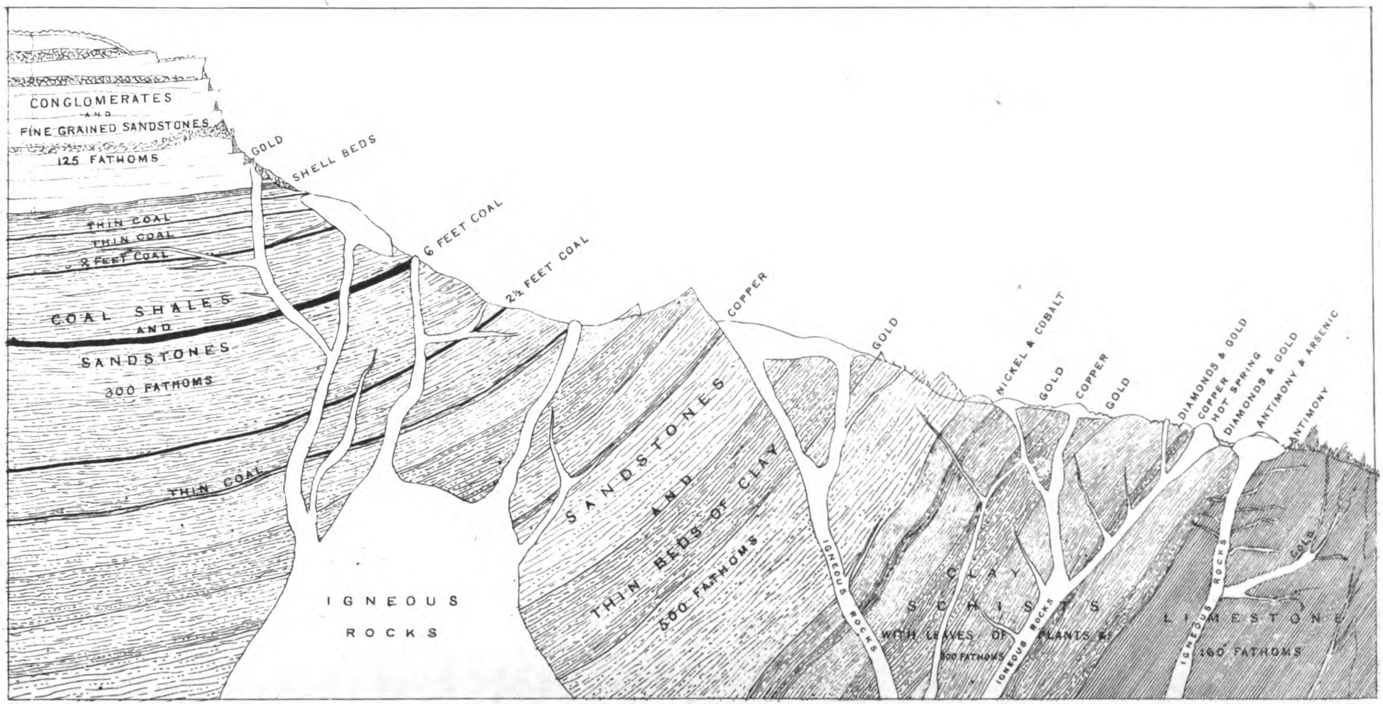

Maclure & Macdonald Lith. Glasgow.

GENERAL SECTION OF TERTIARY ROCKS AND COAL
N.W. BORNEO (SARAWAK)

BY JAMES RUSSELL, MINING ENGINEER.

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PROCEEDINGS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW.

SIXTY-FIRST SESSION.

Andersonian Institution Buildings, November 5, 1862.

The Sixty-First Session of the Philosophical Society was opened this evening,—Professor W. J. Macquorn Rankine, the President, in the Chair.

The President delivered an Address, of which the following is the substance:—

1. This Address may be regarded as a continuation of the reports on "Applied Mechanics," one of which was presented to the Society in 1858 by Mr. J. R. Napier, Mr. W. M. Neilson, and Professor Rankine, while the other formed the Opening Address of the Session 1861-62. To these reports, and especially to the first, the members of the Society are referred for the division and arrangement of the subject.

2. *Materials—Stone.*—The best method of protecting natural stone against decay still continues problematical; for although perishable stone may be protected for a time by having a layer at its surface artificially hardened, the hardened layer often scales off in the end, leaving the stone in a worse condition than before. The protection of natural stone is intimately connected with processes for making artificial stone, some of which were partially mentioned in the address of 1861. One of these, that of Mr. Ransome, consists in working up clean, sharp sand with a viscid watery solution of silicate of soda into a paste in a pugmill, moulding and cutting the paste into the required shape of the blocks of stone, and immersing the blocks so made in a watery solution of chloride of calcium; the chlorine and calcium penetrate by chemical affinity into the heart of the block, producing silicate of lime, which cements the grains of sand into a very hard artificial sandstone, and chloride of sodium, which, being in a state of watery solution, gradually escapes. By another process some-

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what analogous (Messrs. Bartlett's) there is produced, as a cementing material, silicate of alumina, or, as it may be called, artificial felspar.

3. *Materials—Iron and Steel.*—The great utility of recent improvements in processes for making large masses of steel, and of steely iron, at moderate cost, was sufficiently stated in the address of 1861. In the present address the fact may be noted, that the results of such processes formed some of the most remarkable objects in the International Exhibition of 1862, not only in the shape of immense ingots of steel, steel cannon, and the like, but in the shape also of steel used in mechanism, especially that of locomotive engines, so as to obtain strength combined with lightness to a degree unknown before. The Exhibition displayed some very striking examples of the progress recently made by British iron-manufacturers in the art of rolling and forging great masses of iron rapidly, such as wheel-tires, girders, armour-plates, &c. Our experimental knowledge of the strength of iron and steel has received two important contributions—the experiments of Mr. Fairbairn on the factor of safety, in continuation of those already mentioned in the address of 1861; and those of Mr. Kirkaldy, made at the expense of Messrs. Robert Napier & Sons, and published in a very interesting and valuable volume.

4. *Materials—Various Metals.*—The manufacture of certain alloys of copper and aluminium (known as "aluminium bronze") has now for sometime been established as a regular business at Newcastle. These compounds are very useful and valuable, from their great strength, hardness, and durability. Bronze containing about 10 per cent. of aluminium is considerably harder and stronger than cast iron. From some experiments on the strength of pure aluminium, by Professor Tresca, it appears to be of about the same strength with good wrought iron, *weight for weight;* that is to say, being of about one-third part of the heaviness of iron, it is also of about one-third part of the strength, *bulk for bulk.*

5. *Materials—Timber.*—Under this head, little can be added to what is stated in the reports of 1858 and 1861, except that our knowledge of the better kinds of tropical timber, remarkable as they are for strength and durability, continues to increase, and has been promoted by the Exhibition.

6. *Construction—Masonry.*—The most remarkable works of masonry of recent date have taken the form of harbour and sea-works, which will be again mentioned further on. Mention may here be made of the curious and useful method used in France of supporting and striking the centres of bridges by means of sand. The foot of each of the standards or upright posts that support the centre is made cylindrical,

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and fits easily into a cylinder of wrought iron, whose height is about equal to its diameter. The lower part of that cylinder is filled with clean dry sand, which supports the foot of the post. There are four holes in the lower part of the cylinder, which are stopped with corks. When the centre is to be struck, the corks are drawn out, and the sand runs out of the holes, allowing the centre to sink slowly and steadily. Sometimes a wire hook has to be used to loosen the sand. The descent of the centre can be stopped at any moment by plugging the holes.

7. *Construction—Wood-working Machinery.*—The extensive use of machinery for shaping wood appears to be chiefly due to the Americans; but of late years such machinery has been much employed in Britain for a great variety of purposes. The International Exhibition contained some very fine examples of wood-working machinery, but none superior to that which is used at Woolwich Arsenal for making powder-barrels and various other articles, and which was made by an engineering firm in this neighbourhood.

8. *Construction—Foundations.*—In the address of 1861 reference was made to the system of using masses of concrete contained in iron cases for the foundations of buildings under water, and especially to the examples of that system in Mr. Page's bridges at Chelsea and at Westminster. An example of a similar system, on a very large scale, is to be found in the new harbour works now being executed at Greenock by Messrs. Bell & Miller. The frame of the foundations of the piers consists of a series of cast iron piles of H-formed section, tied together from front to back with wrought iron rods; between those piles are placed panels of granite, so as to form a casing enclosing a space, which is filled with concrete. The method of making foundations under water by the aid of vertical tubes containing compressed air, which was invented by M. Triger, a French engineer, and first practically carried out by Mr. Hughes, contractors' agent to Messrs. Fox, Henderson, & Co., at Rochester Bridge, has of late been greatly extended and improved; for instead of the extent of the foundation that is made by means of a given tube being limited by the area of that tube, the foundation is made in a wrought iron chamber of any required figure, and of a size limited by considerations of strength only. One or more tubes or "chimneys" rise from the roof of that chamber, and give access to it for the introduction of men and building materials, and the removal of stuff excavated. This method is employed in founding the abutments of the bridge over the Rhine at Kehl, now in progress under the chief engineers, Messrs. Vuigner and Keller. In the foundation of the French abutment, for example, four oblong

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plate-iron chambers or caissons are used side by side, each measuring about 19 feet × 23 feet, and 12 feet high (the whole area of the foundation being 77 feet × 23 feet). Each chamber has three chimneys. As the digging of the foundation goes on, and the chambers gradually sink into the ground, the building of the masonry of the abutment is carried on upon the top of their roofs, leaving cylindrical wells for the chimneys. When the sinking is complete the chimneys will be removed up and the chambers built up. A method of the same kind is used in Mr. Hawkshaw's bridge at Charing Cross.

9. *Construction—Iron Bridges.*—A mathematical investigation of the theory of the action of a transverse load on a beam has been lately made by Mr. Airy, the Astronomer-Royal, and communicated in abstract to the British Association, and in detail to the Royal Society. It is remarkable, not so much for the novelty of its results, which are in conformity with principles already known and followed, as for the elegance and comprehensiveness of the method by which those results are obtained. The investigation is illustrated by diagrams, in which the directions of principal stress at various points in the interior of a beam are indicated by means of a network of curves. The general nature of such curves had been pointed out by previous authors; but their figures have never before been investigated in so detailed and precise a manner.

A classification of the different kinds of iron bridges has been given in the address of 1861.

Amongst remarkable iron bridges lately erected may be specified the viaduct at Freiburg, in the Canton of Berne, which now occupies the place formerly held by the Crumlin viaduct, of being the highest bridge in the world. It consists of lattice girders, supported on piers, of which the upper part is a skeleton frame of iron, and the lower part is a basement of masonry; the tallest pier is 262 feet high. This viaduct was built without scaffolding, by running the girders on rollers out from the abutment, until their projecting ends were over the site of the first pier; the iron work of the pier was then lowered from the ends of the girders. When the first pier was completed the girders were rolled forward for a distance equal to the span of the second bay, and the ironwork of the second pier lowered from their ends, and so on. The rolling forward of the girders required six hours' work of sixteen men for each bay. The chief engineers were successively M. Jacqmin and M. Durbach; the contractors, Messrs. Schneider & Co.

Colonel Pitt Kennedy has introduced, in constructing railways in India, a system of making all the river bridges of similar parts, differing only in their number, which tends very much towards economy in cost.

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The piers consist of hollow cast iron screw piles, with diagonal bracing; the superstructure of Warren or triangular lattice girders.

10. *Lines of Land Carriage—Roads.*—The construction of common roads has not lately undergone any change; but the method of working them is marked by a revival of the use of steam-power, which has been attended with some success, especially in the case of those heavy road locomotives known as "traction engines," which are very useful for drawing heavy loads at moderate speeds, such as three, four, and five miles an hour. Light passenger steam-carriages have also been tried with success at speeds of ten or twelve miles an hour. Good examples of both those classes of vehicles were shown at the International Exhibition. Street railways or tramways, which have long been extensively used in America, and are there considered of great public use and convenience, have been laid down in various British towns with a very different result, having been in most cases taken up again, on the ground of their being obstructive and dangerous to the ordinary traffic.

11. *Lines of Land Carriage—Railways.*—At the International Exhibition the present state of the manufacture of locomotive engines was illustrated by many excellent examples. The British engines were marked by improvements in detail rather than in principle. Many of the improvements are directed towards the object of enabling locomotives to burn coal without emitting smoke. The use of the feed-pump is to a great extent superseded by that of Giffard's injector. The British locomotives belong to three well-known classes,—heavy traffic engines, with six coupled wheels of moderate size; intermediate traffic engines, with six wheels, four of them coupled; and six-wheeled express engines, with two driving wheels only of large diameter. One of those express engines (by Messrs. Neilson & Co. of Glasgow) has driving wheels of the great diameter of eight feet two inches. Amongst improvements in the details and appendages of locomotives may be mentioned Mr. Ramsbottom's picking-up apparatus, or scoop, for filling the tender with water from a shallow trough between the rails, while running at full speed. It has been found to work well in practice at all speeds, not falling short of twenty-two miles an hour.

The foreign locomotives in the Exhibition, unlike the British, presented many novelties in design, some possessing great merit; the object of most of these inventions being to adapt the engine to sharp curves, steep gradients, and heavy trains. As it would be impossible within the limits of this address to give any useful information as to the very peculiar designs of the foreign locomotives, reference may be made for a general account of them to the *Record of the Exhibition of* 1862, published by Mr. William Mackenzie and Messrs. W. and J. H.

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Johnson; and for the details of some of the most remarkable to two publications entitled respectively *Notice sur les trois Types de Locomotives exposés*, and *Mittheilungen über die zur londoner Ausstellung im Jahre* 1862, *von der k. k. priv. österreichische Staatseisenbahr-Gesellschaft gesendeten Gegenstände;* the former issued by the Northern (France) Railway Company; the latter by the Austrian State-Railway Company.

The nature and advantages of certain self-acting brakes for railway carriages were explained in the address of 1861. To the list of inventions of this class has now to be added that of M. Achard, in which mechanism for causing brakes to act simultaneously on all the wheels of a train is thrown into and out of action at any instant when required, by means of electro-magnetic apparatus, regulated by a conductor which extends along the whole length of the train.

12. *Works for Drainage and Water Supply.*—The most remarkable recent events connected with drainage engineering in Britain have been the destruction, and the re-construction (under the direction of Mr. Hawkshaw), of the outlet of the Middle-level Drainage Canal; but those events have been so fully described by Mr. William Johnstone, C.E., President of the Institution of Engineers in Scotland, in his opening address to that body, whose *Transactions* are presented annually to the library of this Society, that it is sufficient to refer to that address for information on the subject. It may be remarked here, however, that, for the destruction of the Middle-level sluices, no blame can be imputed to the skilful and prudent engineer who designed them (the late James Walker, LL.D.); for their foundations were undermined through a very great but very gradual deepening of the bed of the river Ouse, to an extent which neither he nor any one else could have foreseen when the sluices were executed.

The system of using thimble joints for water pipes, caulked with rings of lead rammed in cold, instead of the usual spigot-and-faucet joints, has been lately tried with good success in France. These thimble joints are very easily and quickly made and unmade, and afford peculiar facilities for removing and replacing single lengths of pipe.

The system invented a few years ago of casting water pipes vertically, with the plain end up, and a head in which the air-bubbles collect, and which is afterwards broken off, presents great advantages.

The recently introduced, but now well-known method of protecting iron pipes against corrosion, by coating them inside and out with pitch, has been found, through experiments by Mr. J. M. Gale, Manager of the Glasgow Corporation Water Works, to possess another advantage;

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it diminishes very materially the friction, which resists the flow of the water through the pipe.

13. *Inland Navigation.*—In this branch of engineering various inventions have of late appeared for using vertical lifts instead of locks. The use of steam-power on canals is gradually increasing. The warping-chain, long known on a small scale as a means of propulsion for short distances, has received of late a prodigious extension, being now employed throughout a large portion of the river Seine, on which it has almost superseded the ordinary tug steamers.

14. *Harbour and Sea Works.*—Under the head of *Foundations* something has already been said respecting improved methods of constructing harbour and sea works. In the address of 1861 the use of great blocks of concrete for the facing of breakwaters has already been mentioned; and it may here be added that, whereas with the largest natural blocks of stone that can be obtained, it is necessary to adopt inclinations such as five to one, or even ten to one, for the sea-slopes of breakwaters exposed to the ocean waves, the use of artificial blocks, of from twenty to forty tons' weight, enables such slopes to stand at an inclination of one to one, and thereby effects an immense saving in materials, labour, and time.

15. *Lighthouses.*—The building of lighthouses presents no novelty in principle: for the structure of all those which have lately been built belongs to one or other of three well-known classes,—the stone tower, the iron tower, or the skeleton frame on piles. The British and French departments of the Exhibition were very rich in models of lighthouses. For a general description of these, reference may be made to the *Record of the Exhibition*, already mentioned; and for details respecting the French lighthouses, to a work published by the French government, entitled *Notices sur les Modèles, Cartes, et Dessins relatifs aux Travaux Publics.* A great improvement has been made in the steadiness and safety of floating lights and beacons, by making their hulls circular or tub-shaped externally, instead of ship-shaped, and by mooring them by their centres of gravity.

The optical apparatus used in the best appointed lighthouses is still constructed according to the principles introduced by Fresnel, with some improvements, the most important and ingenious of which are due to Mr. Thomas Stevenson (see his work on *Lighthouse Illumination*).

The use of the light of the electric discharge instead of that of flame, over which it has many advantages, is now undergoing the test of a practical trial, with every appearance of success.

16. *Motion of Waves.*—The theory of the motion of waves in water is practically important in connection with the construction of sea

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works, and the stability and propulsion of ships. That theory has been recently advanced from an approximate to an exact condition through the publication of investigations by Mr. William Froude, and by the author of this address; the former in an appendix to the report of a discussion in the *Transactions of the Institution of Naval Architects for* 1862, the latter partly in a paper in the same *Transactions*, and partly in a paper read in abstract to the British Association in September, 1862, and in full to the Royal Society soon afterwards. The fundamental principle of which the latter investigation is the development was stated in *A Manual of Applied Mechanics*, published in 1858.

17. *Resistance and Stability of Ships.*—One of the applications of the exact theory of wave-motion in water is to assist in the theoretical computation of the frictional resistance to the motion of a ship through the water; and it has been practically used for that purpose since 1858, as already stated in former reports. The investigations of Mr. Froude upon the stability and oscillations of ships, mentioned in the address of 1861, have been continued during the present year, and corroborated by the researches of Mr. Crossland and the author. (See *Trans. Inst. Naval Architects*, 1862.) The fact that the resistance of well-shaped ships depends mainly on friction shows how important it is that efficient means should be practised of keeping the bottoms of iron ships smooth and clean, and thereby preventing a disadvantage under which they often labour in point of speed, as compared with copper-bottomed wooden ships. Certain compositions are now much used for that purpose, and it is most desirable that authentic and accurate accounts of their effects should be obtained and recorded. It is to be hoped that this will be effected through the inquiries made by the Committee of the British Association on steam-ship performance.

18. *Shipbuilding.*—The principle that the ribs of an iron ship ought to run lengthways rather than crossways has long been established theoretically; but from the distrust with which such improvements are viewed by shipowners, underwriters, and the public, the putting of them in practice involves more risk of pecuniary loss than most shipbuilders are willing to encounter. A very good example, however, of the longitudinal arrangement of ribs has lately been executed by Mr. Scott Russell in a vessel called the "Annette," and will be described in the forthcoming volume of *Transactions* above referred to. In the same volume will be found many papers illustrative of the present condition of shipbuilding, especially as regards armour-plated ships of war.

19. *Perpetual Motions.*—In the report of 1858 the diminution of

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the number of perpetual motions in the patent lists was made matter of congratulation, and a hope was entertained that such delusive inventions might soon disappear. That hope unhappily has not been realized; for the weekly abstracts of specifications of patent inventions seldom even now appear without one or two contrivances, usually called inventions "for obtaining motive power," which are in fact perpetual motions. To the credit, however, of the professional advisers of the inventors, it appears that very few of those patents proceed beyond the stage of provisional protection. The state of mind which is the source of such contrivances is obviously produced by partial knowledge of mechanical details, combined with total ignorance of principles; and the cure for that state of mind is instruction in the principles of mechanics.

It is a curious fact, that just as monsters in the animal and vegetable kingdoms are shown by naturalists to be formed according to definite laws and capable of classification, so perpetual motions can be classed as belonging to a few types, which are reproduced again and again with slight variations, and seem to be the effect of tendencies in the human mind towards certain definite forms of error.

20. *Prime-Movers.*—The President concluded his address by giving a general account of the various sorts of prime-movers exhibited at the International Exhibition, including water-pressure engines, turbines and other water-wheels, windmills, gas engines, air engines, steam engines with their boilers and fittings, and electro-magnetic engines; but as the substance of his remarks has been printed in the report of the Jury, Class VIII., it is unnecessary to repeat them here.

On the motion of Mr. Walter M. Neilson, a vote of thanks was given to the President for his address.

A letter was received from Professor T. Bolzani, of the Imperial Russian University of Kazan, intimating the gift by that University to the Philosophical Society of a series of printed scientific papers, extending (with some imperfections, to be afterwards supplied) from the year 1835 to 1860.

The Society voted thanks to the University of Kazan, and agreed to present to that learned body a copy of the printed *Proceedings of the Philosophical Society of Glasgow.*

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November 19, 1862.—*The* President *in the Chair.*

The following gentlemen were elected members of the Society, viz.: —Mr. Walter Galt, Warehouseman; Mr. Charles H. Bousfield; Mr. Gordon Smith, Writer; Mr. John J. Long, Manufacturer.

Mr. Cockey, the Treasurer, gave in the following Abstract of his Accounts for Session 1861-62:—

Dr.						
1861, *Nov.* 1.						
To Cash in Union Bank and in Treasurer's hands,				£60	8	10
Entries of 13 new Members, at 21s.,	£13	13	0			
Annual Payments,	292	2	0			
				305	15	0
Institute of Engineers, for Rent,				15	0	0
Union Bank for Interest,				2	3	6
				£383	7	4
Cr.						
1862, *Oct.* 31.						
By New Books Purchased, and Binding,				£113	7	1
Printing New Catalogue,				30	0	0
Printing Transactions of the Society,				34	15	0
Printing Circulars, and Stationery,				16	15	0
Salaries and Wages,				116	3	3
Rent, Fire Insurance, and Gas,				53	14	4
Petty Charges, Postages, &c.,				3	6	7
Balance at the Bank and in Treasurer's hands,				15	6	1
				£383	7	4

Dr. Bryce, the Librarian, reported that the number of volumes in the Library is now 3,409, of which 91 were added during the past year.

The thanks of the Society were voted to Mr. Crum and the Directors of Anderson's Institution for their liberal arrangements for the accommodation of the Society.

The Society appointed the following gentlemen to be its Office-bearers for the year 1862-63:—

President.

Professor Henry D. Rogers, LL.D., F.R.S.

Vice-Presidents.

Professor William Thomson, LL.D., F.R.S., and
Mr. Robert Hart.

Librarian.

James Bryce, LL.D., F.G.S.

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Treasurer.

MR. WILLIAM COCKEY.

Joint-Secretaries.

MR. ALEXANDER HASTIE. | MR. WILLIAM KEDDIE.

Council.

PROFESSOR GRANT.
MR. WILLIAM RAMSAY.
DR. ALLEN THOMSON.
MR. HUGH BARTHOLOMEW.
MR. GEORGE ANDERSON.
MR. WILLIAM EUING.
MR. WALTER M. NEILSON.
DR. THOMAS ANDERSON.
MR. ALEXANDER HARVEY.
MR. THOMAS M'GUFFIE.
MR. JAMES M. GALE.
PROF. W. J. M. RANKINE.

Library Committee.

THE PRESIDENT.
PROF. W. J. M. RANKINE.
DR. ALLEN THOMSON.
DR. THOMAS ANDERSON.
DR. JAMES BRYCE, *Librarian.*
MR. WM. COCKEY, *Treasurer.*
MR. WM. KEDDIE, *Secretary.*

The Society voted cordial thanks to Professor Rankine for the able manner in which he had discharged the duties of President during the last two years.

MR. JAMES RUSSELL, Mineral Surveyor, Chapelhall, Airdrie, exhibited the fossil jaw of an unknown animal, from the coal measures in the neighbourhood of Airdrie.

December 3, 1862.—PROFESSOR HENRY D. ROGERS, *the President, took the Chair.*

DR. ROGERS returned thanks for the honour of having been elected President of the Society.

The PRESIDENT mentioned that the undescribed fossil referred to in the last minute had been sent to London for inspection, and that, from the proportional size and structural features of the teeth, and from the general contour of the skull, as well as from an examination of some of the vertebræ and ribs, Professor Huxley had concluded this to be a new genus of Labyrinthodonts, to which he assigned the name of Anthracosaurus. The name given to the species is *Anthracosaurus Russelli.*

The following gentlemen were elected members, viz.:—Mr. James Couper, 132 West Regent Street; Mr. Josiah M'Gregor, Engineer, 10 St. George's Road; Dr. James B. Russell, Royal Infirmary; Mr. Thos. Martin, Bookbinder, 6 Ann Street, Jamaica Street.

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The following were appointed a Committee to make arrangements for a *Conversazione* of the members of the Society and their friends, viz.:—Mr. James Allan, Mr. Thomas M'Guffie, Professor W. J. Macquorn Rankine, Mr. Walter M. Neilson, Dr. Bryce, Mr. William Ramsay, Dr. Francis H. Thomson, Mr. Keddie—Mr. George Anderson, Convener.

Dr. Bryce read an "Account of Excavations within the Stone Circles of Arran."

Mr. Clark, Curator of the Royal Botanic Garden, exhibited the Nardoo Plant (*Marsilea macropus*) of Australia.

December 17, 1862.— *The* President *in the Chair*.

Mr. Charles R. Lawson, Engineer, 113 Greenhead, was elected a member of the Society.

Mr. James Napier, Chemist, read a paper on the Clay and Blackband Ironstones.

Black and Clayband Ironstones: their Composition and Valuation.

By James Napier, Esq., Chemist.

In 1801 David Mushet made the discovery of the Blackband Ironstone, and in describing it in 1840, he says,—"In the discovery of what is now called Blackband Ironstone, an entirely new class of ironstones, to which I have given the name 'Carboniferous,' has been introduced to the iron trade and to the mineralogist; others have termed it 'bituminous,' but this designation is not, so far as I have seen or known, at all appropriate. In fact, all ironstones of this kind that have hitherto come under my notice, may be considered as a species of coal, which, when exposed to combustion, yield a greater or lesser quantity of smoke and flame, leaving behind what may be termed a metallic coke. The different beds generally contain a sufficient quantity of carbonaceous matter to torrify the stone, and make it fit for the furnace. Most of the beds possess a top measure, which is more carboniferous than the lower measure—more resembling a carboniferous schist; and, in proportion as it contains volatile matter resolvable into flame, so is its per centage of iron reduced. The fracture of the lower part of the bed generally presents gray and black layers alternating."

As these two classes of ironstones differ materially in their working properties in the smelting furnace and the quality of their product,

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they deserve and receive a different value in the market. It is therefore of considerable importance, both to buyer and seller, to ascertain with certainty to which class any ore exposed for sale really belongs. The common rule for ascertaining whether an ore is a black or clayband, is no doubt partly deduced from Mr. Mushet's description, making what he calls merely a general rule, "That they contain sufficient carbonaceous matter to torrify them," into a definite rule. Thus, in Mr. Page's book on *Geological Terms*, he says,—

"Clayband is a familiar term for the impure earthy carbonates of iron which occur in nodules, layers, and bands, chiefly in the coal formation, hence clayband in contradistinction to blackband."

"Blackband," says the same author, "is a Scotch miner's term for those ironstones (clay carbonates) of the coal measures which contain coaly matter sufficient to calcine the ore without any artificial addition of fuel."

This method of determining a blackband from a clayband I think too loose and indefinite to form the basis for valuing such an important article as iron ores. When it is considered that the royalty for blackband is about double that for clayband, such a difference of price should have a more definite line of distinction than a few, and that an uncertain few, per centages of coal; for the real per centage of coaly matter required to calcine the ore will vary according to whether the coal is diffused equally through the ore or exists in bands or stripes. Besides, this arbitrary method of classifying iron ores to determine their value throws some very valuable ores into the inferior class of clayband, as the following analysis will illustrate:—

	No. 1.	No. 2.	No. 3.
Oxide of Iron, .	38·8	53·0	40·8
Clay matter, .	17·0	2·0	10·0
Lime and Magnesia,	12·0	5·0	2·0
Coaly matter, .	1·9	8·0	17·5
Metallic Iron, .	30·1	41·2	31·7

No. 1, Clayband; No. 3, Blackband; No. 2 is a rich band, best of the three, and yet, by the above rule, is a clayband. I may mention here that there is another acknowledged distinction of a blackband that often decides its class, even although the coaly matter may not be up to the required quantity for calcination, based on another statement of Mr. Mushet, "That the fracture of the lower part of the bed generally presents gray and black layers alternating." Thus the composition is laid aside, and the physical structure of brown and black stripes is made to fix its class, and, consequently, its price. This structure often

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occurs in ores that are more closely allied in their composition to clay than blackbands, forming a sort of link between them. Indeed, taking all the kinds of iron ore together, it is interesting to mark how the one sort runs into the other in their composition, and, although the two extremes are far apart, still to draw a line of definition, and say where the one class begins and the other ends, is not an easy task.

I have selected a few analyses characteristic of each class of ores referred to, both to illustrate the principle of valuation which I mean to suggest, and as a comparison of the ores in use forty years ago and at present. The first table contains analyses of claybands made by Dr. Colquhoun, a member of this Society, published about thirty-seven years ago, keeping out as unnecessary in this inquiry carbonic acid and fractions of manganese, &c., and the second table recent claybands.

	Protoxide Iron.	Silica.	Alumina.	Lime.	Magnesia.	Coal.	Metallic Iron.
Claybands; by Dr. Colquhoun, 1827.	35·2 45·8 42·1 38·8 36·5	9·6 7·8 9·7 10·8 19·9	5·3 2·5 3·8 6·2 8·0	8·6 1·9 4·9 5·3 2·0	5·2 5·9 4·8 6·7 2·7	2·1 1·8 2·3 1·9 2·1	27·3 35·6 32·5 30·1 28·2
Average,......	39·7	11·8	5·1	4·5	5·0	2·0	30·3
Recent Claybands.	42·2 41·8 42·5 44·5 40·2 44·0	8·4 6·0 6·8 7·5 11·6 4·0	6·6 6·1 3·6 4·7 7·6 2·1	4·8 7·8 8·0 3·8 3·3 7·0	0·6 2·7 1·0 1·0 2·3 1·0 5·0	2·7 2·2 2·9 3·2 1·6 3·0	32·8 32·5 33·0 34·5 31·1 34·2
Average,......	42·6	7·4	5·1	5·8	2·2	2·6	33·0

From these analyses it will be seen that the clayband ironstones of the present day—at least those in the immediate neighbourhood of Glasgow—are superior to the claybands of forty years back, not only in having 3 per cent. more iron, but the relation of lime to the silica—an important consideration—is greatly in favour of the recent ores. It would require about three times the lime to make a good slag with the old ores as with the recent.

The next table exhibits the class I have just referred to, that are called blackbands, because they are striped black and brown. I may mention that most of the really good blackbands are striped.

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	Protoxide Iron.	Silica.	Alumina.	Lime.	Magnesia.	Coal.	Iron Metal.
Striped Ores,	45·0	8·1	4·4	4·5	1·2	6·5	35·0
	46·5	9·0	4·6	3·5	0·7	6·6	36·2
	46·5	6·8	4·4	1·3	0·6	5·8	36·2
	48·2	6·8	3·3	—	—	5·6	37·5
Average,.....	46·5	7·7	4·2	2·4	0·6	6·1	36·2

The average composition of these ores shows a value very little above the claybands, certainly not so much above as to deserve double their price; it will also be seen, by comparing the lime with the silica, that such ores will require a good proportion of lime more than the claybands to make a good working slag.

The next table contains analyses of the rich bands referred to.

	Oxide Iron.	Silica.	Alumina.	Lime.	Magnesia.	Coal.	Iron as Metal.
By Dr. Colquhoun.	53·0	1·4	0·4	3·3	1·7	3·0	41·2
	54·0	1·0	0·5	3·3	0·8	5·0	42·0
Recent.	54·3	6 0	5·2	0·8	0·3	2·0	42·2
	53·0	2·3	1·7	2·4	0·4	2·5	41·2
	54·0	0·6	0·2	2·5	—	4·5	42·0
Average,.....	53·6	2·3	1·6	2·5	0·6	3·4	41·7

To classify these amongst the claybands, as the common rule necessitates, is unjust.

The next table is the composition of the true blackband by the common definition.

	Oxide Iron.	Silica.	Alumina.	Lime.	Magnesia.	Coal.	Iron as Metal.
By Dr. Colquhoun.	40·8	Clay.	10·0	0·9	0·7	17·4	31·7
	39·4	0·8	—	0·6	—	33·0	30·8
Recent.	43·3	0·7	0·3	1·0	—	27·0	33·6
	49·6	1·2	0·8	1·5	0·7	14·6	38·5
Average,.....	45·4	0·7	2·7	1·0	0·3	23·0	33·6

In the valuation of ironstones I think there are considerations more important than the presence of a few per cents. more or less of coal. Coal is no doubt important both for its own value in calcination, and indirectly in being dissipated in this operation, and so making a more concentrated cinder; but the presence of certain earths that are retained in the cinder, and must pass through the smelting operations, is of greater importance directly to the smelter, as these

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earths have all to be fused, and often additional matters have to be added in order to flux or fuse them, which have all a tendency, less or more, to deteriorate the metal obtained, and thus the different earthy matters and their relations to each other in reference to fusion should be particularly considered in the valuation of ores.

The average composition of good slags that have come under my observation was—

Silica, 40; Alumina, 13 = 53;
Lime, 33; Magnesia, 7 = 40;

not including small portions of other bases.

Now, suppose we take an ore of the average composition of the recent claybands, 100 tons raw ore will produce 66 tons calcined cinder, requiring 2 tons lime in smelting to make a slag equal to that quality stated, so that 68 tons have to be fused for 33 tons iron.

One hundred tons of the striped or earthy blackband will produce 66 tons calcined cinder. This will require 6 tons extra lime to make a good slag: thus 72 tons have to be fused for 36 tons iron.

One hundred tons of the rich bands will produce 66 tons of calcined cinder, requiring no lime addition, giving 41·7 tons iron.

One hundred tons of blackband will produce 55 tons calcined cinder, requiring 1 ton additional lime to make good slag—thus 56 tons fused for 33·6 tons iron.

It will thus be seen that the two first ores yield one-half of the quantity fused as metal, and the two latter ores two-thirds of the quantity fused as metal—a most important difference to the smelter, besides the effect these matters have on the quality of metal produced.

I think all iron ores should have a relative value, depending on their composition, instead of by a classification depending upon a substance not essential to the smelter; and for this purpose I would offer the following suggestions, premising that I do not mean the price I have here fixed upon, either for royalty or for the direct purchase of the ore, whether raw or calcined, and delivered at the smelting furnaces, as being the actual price, but merely to illustrate the principle of valuation.

In the first place, all the earths in the ore are impurities, whether silica, alumina, lime, or magnesia: all of them add to the weight and the bulk, and have to be fused to free them from the iron. I therefore propose to deduct the average cost of fusing these from the value of the iron, and as large quantities of these deteriorate the quality of the metal, the iron in the ore, by this method of valuation, is made cheaper to the smelter. For royalty, I have supposed the value of the iron in the ore to be 1½d. per unit per ton, deducting 1d. per unit per ton for all the earths; and for

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sale, delivered free at furnaces, 4d. per unit per ton for the iron, subject to the same deductions for the earths. Thus, take the average of the Old Claybands:—

For Royalty,	30·3 per cent. iron, @ 1½d.,	=	45½
	26·4 „ earths, @ 1d.,	=	26½
			19, or 1s. 7d. per ton.
For sale,	30·3 per cent. iron, @ 4d.,	=	121¼
	26·4 „ earths, @ 1d.,	=	26½
			94¾, or 7s. 10¾d. per ton,

or 26s. 1d. per ton of iron per cent. in the ore.

RECENT CLAYBAND.

For Royalty,	33·0 per cent. iron, @ 1½d.,	=	49½
	20·5 „ earths, @ 1d.,	=	20½
			29, or 2s. 5d. per ton.
For sale,	33·0 per cent. iron, @ 4d.,	=	132
	20·5 „ earths, @ 1d.,	=	20½
			111½, or 9s. 3½d. per ton,

being 28s. 4d. per ton of pure iron in the ore.

EARTHY STRIPED BANDS.

For Royalty,	36·0 per cent. iron, @ 1½d.,	=	54
	14·9 „ earths, @ 1d.,	=	15
			39, or 3s. 3d. per ton.
For sale,	36·0 per cent. iron, @ 4d.,	=	144
	14·9 „ earths, @ 1d.,	=	15
			129, or 10s. 9d. per ton,

or 29s. 10d. per ton of pure iron.

RICH BANDS.

For Royalty,	41·7 per cent. iron, @ 1½d.,	=	62½
	7·1 „ earths, @ 1d.,	=	7
			55½, or 4s. 7½d.
For sale,	41·7 per cent. iron, @ 4d.,	=	166·8
	7·1 „ earths, @ 1d.,	=	7·0
			159·8, or 13s. 3¾d.

31s. 11d. per ton of iron.

BLACK BAND.

For Royalty,	33·6 per cent. iron, @ 1½d.,	=	50½
	4·7 „ earths, @ 1d.,	=	4¾
			45¾, or 3s. 9¾d.
For sale,	33·6 per cent. iron, @ 4d.,	=	134·4
	4·7 „ earth, @ 1d.,	=	4·7
			129·7, or 10s. 9¾d.

Iron 32s. 2d. per ton.

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All ores should be valued by the analyses and produce of the raw ore, and to know the cost per ton of calcined ore by this means, it does not require new testing, but simply to know the loss of weight by calcination. If, as in this last ore, 100 tons yield 55 tons of calcined cinder, then the cost of 100 tons, being divided by 55, will give the value.

Looking upon these rich bands and the blackband, there is an apparent difference in favour of the rich band over the black, although the latter have coal sufficient to calcine it; but if we take the value of the iron in each, it will be found that the iron in the blackband is paid for at a higher rate, the difference being nearly equal to the value of the coal required to calcine the rich band.

Again, the earthy or striped bands appear nearly of the same price as the true, or best blackband, although they have an additional 10 per cent. of earths; but the value of the iron is different; and, as observed already, in fusing 100 of the striped with flux, there will only be 50 tons iron, while the fusing of 100 tons of blackband gives 60 tons iron.

There may appear a difficulty in getting a fair average sample of ore for testing, to ascertain its value; but this operation, if done just before a heap is kindled for calcination, is so simple and inexpensive, and, with ordinary care, so accurate, I do not think it worth considering; and, although it was more difficult than it really is, the positive knowledge that the smelter would have of the composition of his ores would compensate for any ordinary trouble and expense, as it could not fail to prove of the greatest advantage to him, both for economizing and improving the smelting operations. It is not an uncommon circumstance to find slags with an unnecessary excess of lime. Now, every ton of lime added by the smelter will cost him at least 10s. The relation of the lime to the silica in good slag is about 80 lime to 100 silica. I have seen analyses of slag having 109 lime to the 100 silica, and 90 and 95 to 100 is a common occurrence. I have also seen slag with only 42 lime to 100 silica. In this case, however, there were from 6 to 8 per cent. oxide of iron present, and the metallic iron produced contained 8 per cent. of silica. My impression is, that such things as these take place from a rule of thumb method of proceeding on the part of the smelter, and would not possibly take place, without unpardonable carelessness, under such a system as I have suggested, as the smelter, having a thorough knowledge of his ores, could mix them, or otherwise, to the best advantage as to fluxing, and need never fail in producing a uniformity of slag, and also a uniformity in the quality of the metal produced.

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Messrs. Gruner and Lan, in an elaborate investigation into the manufacture of pig iron in Scotland, gives, as the average for the years 1859-60, $34\frac{1}{2}$ cwt. calcined ore for one ton of pig iron, equal to 16s. 9d. per ton of calcined ore. The pig iron produced is said to have 94 of pure iron and 6 impurities, so that from this the calcined ore, by analysis, would give 54·5 iron, and would have 23 earths at least. Now, by my method,

$$\begin{array}{l} 54{\cdot}5 \text{ @ 4d.,} = 218 \\ 23{\cdot}0 \text{ @ 1d.,} = 23 \\ \hline \phantom{23{\cdot}0 \text{ @ 1d.,} = } 195 = \text{16s. 3d. per ton of calcined ore.} \end{array}$$

MR. JAMES R. NAPIER read a paper on Sections of Least Resistance in Ships of Limited Breadth and Draft of Water.

On Sections of Least Resistance for Ships of Limited Breadth and Limited Draft of Water. By MR. JAMES ROBERT NAPIER.

As the friction of water along the submerged surface of ships forms an important part of the resistance to be overcome, it is desirable that this surface be the smallest possible consistent with other conditions.

The common problem of passing a curve of a given length through two points so as to enclose the greatest area between the curve and the straight line joining the points, may be applied to the construction of all vessels whose breadth and draft of water are not limited.

But there are many cases where both the breadth and draft of water are limited, it may be by the width of dock entrances and the depth of rivers. Then the problem becomes, to enclose within a rectangle of a given breadth and depth the greatest area with the least wetted boundary, that the enclosed area, divided by the wetted boundary, may be a maximum; for then, whatever form it may be considered necessary to give to the water lines, the vessel of this breadth and draft of water, with this midship section, these water lines, and with the narrower sections constructed on the same system, will have the greatest displacement or volume below water with the least surface for friction, and therefore the least resistance. In this sense I have called them sections of least resistance.

To construct these sections, the problem reduces itself to finding the radius of bilge, which, with the given breadth and draft of water, shall complete the section, whose area, divided by the wetted boundary, shall be a maximum.

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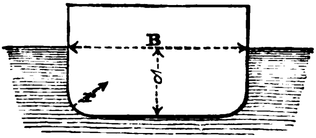

Let B be the breadth of the vessel.
δ the draft of water.
r the radius of bilge.

$$\frac{\text{Area of section}}{\text{Wetted boundary}} = \frac{B\,\delta - 0{\cdot}429\,r^2}{B + 2\,\delta - 0{\cdot}858\,r} \text{ is to be a maximum.}$$

Therefore,

$$\frac{0{\cdot}858\,r\,d\,r \times \text{denominator} - 0{\cdot}858\,d\,r \times \text{numerator}}{(\text{Denominator})^2} = 0$$

$$\therefore r \times \text{denominator} = \text{numerator}$$

$$(B + 2\,\delta)\,r - 0{\cdot}858\,r^2 = B\,\delta - 0{\cdot}429\,r^2$$

$$0{\cdot}429\,r^2 - (B + 2\,\delta)\,r = -B\,\delta$$

$$r^2 - \frac{(B + 2\,\delta)\,r}{0{\cdot}429} = -\frac{B\,\delta}{0{\cdot}429}$$

A quadratic equation from which the radius r is found,

$$r = \frac{B + 2\,\delta - \sqrt{B^2 + 4\,\delta^2 + 2{\cdot}284\,B\,\delta}}{0{\cdot}858}$$

Examples.—When $\delta = 4\,B \quad r = 0{\cdot}114\,\delta$ when $\delta = \infty \quad r = \frac{B}{2}$

$$\begin{array}{llll}
\delta = 2\,B & r = 0{\cdot}23\,\delta & \qquad & B = \infty \quad r = \delta \\
\delta = B & r = 0{\cdot}35\,\delta & & \\
\delta = \frac{1}{2}\,B & r = 0{\cdot}54\,\delta & & \\
\delta = \frac{1}{3}\,B & r = 0{\cdot}63\,\delta & & \\
\delta = \frac{1}{4}\,B & r = 0{\cdot}70\,\delta & &
\end{array}$$

By describing sections in a rectangle whose breadth equals twice its depth, it will be found that

$$\frac{\text{Area of rectangle}}{\text{Wetted boundary}} = \frac{2\,\delta^2}{4\,\delta} = 0{\cdot}5$$

$$\frac{\text{Area of semicircle}}{\text{Wetted boundary}} = \frac{\frac{1}{2}\,\pi\,\delta^2}{\pi\,\delta} = 0{\cdot}5\,\delta$$

$$\frac{\text{Area of best section}}{\text{Wetted boundary}} = \frac{2\,\delta^2 - 0{\cdot}43 \times (0{\cdot}54\,\delta)^2}{4\,\delta - 0{\cdot}86 \times 0{\cdot}54} = 0{\cdot}531\,\delta\,;$$

showing that when the radius of bilge is 0·54 times the draft of water, there is a gain of about 6 per cent. over the semicircular or rectangular section.

Professor Macquorn Rankine said that he had revised the mathematical investigation in Mr. Napier's paper, and could corroborate its accuracy. Its practical utility arose from the fact that the whole, or

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nearly the whole, of the resistance to the motion of a well-shaped ship arose either directly or indirectly from friction. A theory based on that fact had been applied to practice in designing steam-ships and their engines by Mr. Napier and himself, in December, 1857, and subsequently, and in every instance with success. He had read a paper giving a general account of the theory, and an explanation of the practical formulæ deduced from it, with tables of comparison between their results and those of experiment, to the British Association in 1861. That paper was published entire in the *Civil Engineer and Architect's Journal* for October of that year, and, in part, in other engineering periodicals also. The theory was connected with some researches on the motion of waves, which were read in abstract to the British Association, and in full to the Royal Society in 1862.

As might be expected in a theory whose practical application was only four years and a half old, various questions still remained to be settled by experiment. A serious obstacle in the way of obtaining exact experimental data as to such questions arose from want of precision in the indicator-diagrams of steam engines, especially in engines of rapid stroke, which was produced partly by the friction of the indicator, but chiefly by the oscillations of its spring. One of the best means of diminishing the extent of these oscillations, and the effect of friction at the same time, was to increase the stiffness of the spring and diminish the mass of the indicator-piston. He had seen at the International Exhibition an indicator (that of Mr. Richards) in which that principle had been adopted, and, so far as he could judge from having seen it in action two or three times, with very good results in point of precision.

A comparison of the diagrams given by a very accurate indicator applied to the engines of such vessels as the "Admiral," the "Athanasian," the "Lancefield," &c., would settle some very important points regarding the comparative advantages of straight and hollow water lines, &c. Unfortunately, when vessels were engaged in trade it was difficult to find opportunities for making scientific experiments upon them.

The special subject of Mr. Napier's paper, however, was not one of these problematical points; for there could be no doubt that to diminish a vessel's mean girth, as compared with her sectional area, was a certain means of diminishing resistance; that principle, indeed, had been admitted ever since friction had been recognized as one of the causes of resistance; and Mr. Napier's investigation showed how to carry that sort of diminution as far as possible under the circumstances stated by him, viz., a fixed extreme breadth and draft of water.

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The importance of smallness of girth in diminishing resistance was strikingly shown in the case of the well-known match between the yachts "Titania" (now called the "Themis") and "America." The "Titania" was the smaller vessel of the two, and had the less capacity for carrying sail; and in order to make her speed equal to that of the "America," her friction ought to have been less in the same proportion with her capacity for carrying sail. But while the cross-sections of the "America" were nearly triangular, those of the "Titania" were formed by ogee curves of great concavity, producing a comparatively large girth relatively to her capacity; and that although the "Titània" had a smaller midship section than the "America," the quantity called the "augmented surface," upon which the friction depends, was almost exactly equal in the two vessels, and hence the "Titania," having the less power of carrying sail, was beaten in the race.*

Professor W. Thomson said that he was glad to find that true principles as to the resistance experienced by solids moving through fluids were being applied in practice with such valuable results. The theory which had been hitherto commonly given in treatises on hydrodynamics, was founded on a calculation in which only the front part of the surface of the moving body was taken into account. It was no doubt convenient to neglect the action on the remainder of the surface; for to have included it in the account would have led to the awkward result *of no resistance at all!* Such a theory clearly is wanting in some essential. This we now know to be the reckoning of effects due to the viscosity of the fluid. A probable hypothesis as to the law of viscous force having been adopted, a perfect theory of the motion of a solid through a fluid, at a slow rate, *when no eddies are formed*, had been indicated and worked out in some important cases by Professor Stokes. It gives a resistance simply proportional to the velocity. But when the motion is so rapid as to give rise to eddies, which it always is in practical cases of water flowing through pipes and of ships, the circumstances become extremely complicated. Professor Thomson believed that the principles for obtaining practical solutions for the cases of ships were those which Mr. Napier had used in his investigation now before the Society. He concluded by saying that he had had much pleasure recently in testing, by personal experience of a voyage in the "Lancefield," some of the results of the application of these principles.

Mr. Napier said, that before commencing the construction of the "Admiral," to which Professor Rankine has referred, he applied to

* The "Titania" or "Themis" here referred to is the "Old Titania." The yacht now called the "Titania is a vessel of a better model.—W. J. M. R.

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Professors Thomson and Rankine for advice as to the power necessary to propel vessels of any form, as his own experience led him to disbelieve the common theories based on the midship section or displacement. Professor Thomson stated then what he has now said regarding the friction of water, and Professor Rankine said, that if the resistance was the same as water in a pipe, the power required to propel his vessel at the given speed would be so many horse. The idea of water in a pipe having anything to do with the speed of a boat was strange and new to him; nevertheless, the power named was about two-thirds of what he had estimated to be necessary. A few days after making this approximation to the power, he had from Professor Rankine a formula, to which his notes supplied the data. This formula enabled him to make a vessel whose success was unprecedented.* The lines of the vessel were trochoids, with a cylindrical or prismatic middle, and as the breadth was unlimited and the draft of water limited, he made the radius of bilge equal to the draft of water, so as to have the surface a minimum. The "Athanasian" is also a trochoidal vessel, with a very short prismatic middle, and sections giving a minimum of surface. The "Lancefield" is similar to the "Athanasian," except the bow, which is a wedge, touching the trochoids at their points of contrary flexure. There are other peculiarities, however, in the "Lancefield" to which some of the economical results described by Professor Thomson may be due.

January 14, 1863.—John Hart, Esq., *Vice-President, in the Chair.*

Mr. James Miller, 185 Crown Street, and Mr. David Rowan, 65 St. Vincent Street, were elected members.

Dr. Anderson exhibited specimens of the Oxide of Thallium, and of the Lithia residue from which Rubidium is obtained, and traced the history of the discovery of these bodies.

Mr. Keddie read a "Note on the discovery of a Vitrified Fort at Portencross or Ardneill, in Ayrshire, and on the Fort in the Kyles of Bute."

January 28.—*The* President *in the Chair.*

The following gentlemen were elected members, viz.:—Lieutenant Edward W. Hawes, R.N.; Mr. Thomas Brown, jun., Accountant; Mr. James Miller, Port-Dundas Pottery; Mr. James M'Gregor, Queen's Hotel; Mr. David More, Engineer, 33 Montrose Street; Dr. James

* See Report of Trial Trip in *The Engineer*, 18th June, 1858.

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Gray, 15 Newton Terrace; Mr. George C. Foster, Anderson's University; Mr. Matthew Gray, Calico Printer, Bonhill.

The Rev. Mr. Crosskey read "Notes on the Glacial Beds of the Clyde and its neighbourhood," the paper being amply illustrated by specimens.

February 11.—This evening the members and friends of the Philosophical Society, in conjunction with those of the Institute of Engineers in Scotland, held a *Conversazione* in the Queen's Rooms. By the mutual efforts of the joint-committee appointed by the two Societies, numerous objects of interest were exhibited, including drawings, photographs, articles of vertu, antiquities, models, machines, processes, geological specimens, &c. The attendance of ladies and gentlemen was limited only by the capacity of the rooms.

February 25, 1863.—Robert Hart, Esq., *Vice-President, in the Chair.*

The Society appointed the following Committee to co-operate, in any way which may be deemed suitable, with Bailie Blackie's Committee of the Town Council, on the subject of Libraries and Museums, viz.:—Professor Rogers, Dr. Thomas Anderson, Dr. Allen Thomson, Dr. Taylor, Mr. George Anderson, Mr. William Keddie—Mr. Anderson, Convener.

Mr. John Mayer read a paper on the Government Scheme for aiding Instruction in Science.

The Government Scheme for Aiding Instruction in Science. By Mr. John Mayer.

The members of the Glasgow Philosophical Society can scarcely be expected to remain uninterested regarding a scheme which has for its object the granting of Government assistance to enable the industrial classes of this country to provide themselves with instruction in various branches of practical science. A scheme with such an object is already in existence, quietly and unostentatiously working its way amongst those for whom it was designed; and it is proposed in the present communication to the Society to give an outline of its nature and working, in the hope that some interest in its favour may be excited amongst the members, many of whom have ample opportunity of assisting to make it successful in what it proposes to accomplish.

There are comparatively few persons who, if they give an ordinary amount of attention to contemporary events in our own country, have

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not heard something of the Government Department of Science and Art. It is this department whose habitation is the Brompton "Boilers," in immediate proximity to the International Exhibition Building at South Kensington. Its existence may be said to date from, and to be owing to the recommendation of the commissioners of, the Great Exhibition of 1851, when it was found that the professional instruction given to our own artist-workmen was insufficient to fit them to compete successfully, in some respects, with those of some foreign countries, particularly France and the United States of America; and it was deemed highly desirable that the then existing Schools of Design should be placed under some proper organization, and the art-education imparted in them brought up to that point which was absolutely necessary to enable us to come out with more credit to ourselves as a nation in all future struggles with the rest of the civilized world for pre-eminence in works of art and skill. In this desire no one expressed a greater anxiety than the late Prince Consort, and it was doubtless due to the lively interest which he took in all such matters that the Department of Practical Art was instituted, ten or eleven years since. It was placed under the Board of Trade, and located in Marlborough House, with Mr. Henry Cole and Dr. Lyon Playfair as its joint-secretaries. The Schools of Design were re-organized, and others established in the great industrial centres throughout the country. In course of time it was itself re-organized, and came forth as the Department of Science and Art, to be charged, in addition, with the control of various scientific institutions that were supported in whole or in part from the public funds, but which were under different Departments of the Government. The institutions in question embrace the following:—The Geological Survey, Museum of Practical Geology and Government School of Mines; the Museum of Irish Industry and Royal Dublin Society, with its Botanic Garden at Glasnevin, and Zoological Gardens in Phœnix Park; the Industrial and Natural History Museums, Edinburgh; Navigation Schools in various large seaports; and a number of Trade and Mining Schools in the manufacturing, mining, and pottery districts.

The amount of labour, in the shape of superintendence, &c., that ultimately devolved on the Science and Art Department, necessitated much ampler accommodation than was afforded by Marlborough House; and in 1857 it found a sort of settled home in the iron building erected on the Kensington Gore estate, by Sir William Cubitt, for the commissioners of the Exhibition of 1851. This building, together with several permanent additions by Captain Fowke, the architect and engineer of the Department, now contains the Offices of

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the Department, the Central Metropolitan School of Art, and the Museum, which embraces several collections both of science and art; while the Department itself is now, with more appropriateness, transferred to the direction of the Committee of Council on Education.

So much being premised regarding the nature and history of the Department of Science and Art, we may now proceed to the more immediate object of this paper.

It seemed desirable, in course of time (doubtless to the practical and far-sighted mind of Dr. Playfair, while he was still one of the joint-secretaries of the Department), that something should be done towards providing systematic instruction in Science for the industrial classes, on a more extensive scale than had hitherto been attempted by the Department,—that, in short, science should be put on as good a footing as art, so as to foster the development of scientific skill as well as artistic taste. Hence, in 1859, a scheme was matured, with this most laudable object in view; but not, however, until Dr. Playfair had resigned his secretaryship for the more congenial office of Professor of Chemistry in the University of Edinburgh, rendered vacant by the death of Dr. Gregory.

The scheme in question may be regarded in a two-fold aspect,—*first*, as it affects the teacher, and *secondly*, as it affects those whom he teaches. There can be no successful teaching unless there are properly-qualified instructors; and hence provision is made in the first place for securing a staff of persons who can be recommended to localities in which a desire is expressed for scientific instruction. The Department undertakes to grant certificates to all candidates who satisfactorily pass an examination in the subject or subjects which they wish to teach. For this purpose examinations are held annually in November, at South Kensington, in the following subjects, and for the awards the persons named are responsible, as they conduct the examinations :—

	Subjects.	Examiners.
Group I.	I. Practical, Plane, and Descriptive Geometry, II. Mechanical & Machine Drawing, III. Building Construction,	Prof. T. Bradley.
,, II.	I. Theoretical Mechanics, II. Applied Mechanics,	Rev. B. M. Cowie, B.D.
,, III.	I. Acoustics, Light, and Heat, II. Magnetism and Electricity,	Prof. Tyndall, F.R.S.
,, IV.	I. Inorganic Chemistry, II. Organic Chemistry,	Dr. Hofmann, F.R.S.
,, V.	I. Geology, II. Mineralogy,	Prof. Ramsay, F.R.S. W. W. Smyth, M.A., F.R.S.

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	SUBJECTS.	EXAMINERS.
Group VI.	I. Animal Physiology, II. Zoology,	PROF. HUXLEY, F.R.S.
,, VII.	I. Vegetable Physiology and Economic Botany, II. Systematic Botany,	DR. LANKESTER, F.R.S.
,, VIII.	I. Mining, II. Metallurgy,	W. W. SMYTH, M.A., F.R.S. DR. PERCY, F.R.S.

The subjects are of an eminently practical character, and no one can deny that the examiners are all men of great distinction in the branches of science which they respectively pursue. When the members present glance at the papers set at the Examinations last November, and which I now submit to their inspection, they will doubtless agree that teachers who can pass such tests with credit will not be deficient in the principles of science and their application in the practical pursuits of life. Candidates may be examined in any or all of the subjects named, and according to their success they receive first, second, or third grade certificates, or they are "plucked," and for the time being rejected. They may offer themselves at future examinations; to try again if formerly unsuccessful; to improve the character of their certificates if of the second or third grade; or to be examined in other subjects. In November, 1859, the first examination was held. There were 57 candidates, and as a number entered for two or more subjects, there were in all 115 entries. Forty-three persons were successful in gaining amongst them 66 subdivisional certificates, 14 first grade, 20 second grade, and 32 third grade. In the following year (1860) there were 89 candidates, of whom 75 were successful; and 22 first grade, 44 second grade, and 55 third grade certificates were taken, making 121 in all. There was an increase of 60 per cent. on the number of candidates in 1859, and of nearly 100 per cent. in the certificates taken, though the examination papers were more difficult. In 1861, 103 candidates presented themselves; 57 were new candidates, the remaining 56 had certificates previously. Ninety-seven out of the 103 were successful; and these gained 175 subdivisional certificates. When it is remembered that in 1861 a large number of candidates attended the examinations to improve the grade of the certificates they already possessed, it is not so very surprising to find the numbers of the certificates in the different grades to be 51, 78, and 46, as against 22, 44, and 55 in 1860.

Those teachers who are successful in obtaining certificates at the annual examinations, have their expenses paid by the Science and Art Department,—second class railway fare to and from London, and 10s. per day for personal expenses for every day they require to be occupied by the examination.

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Hitherto the candidates have been almost exclusively from the Metropolis and from various parts of England, and hence we may conclude that the great inconvenience of travelling from Scotland to London has to some extent deterred candidates from this part of the empire "putting in an appearance" at the examinations. In the first year, 1859, the only person from Scotland was the person who now addresses you. The following year there were no candidates from Scotland; but in 1861 there were four candidates hailing from north of the Tweed, including myself, who went to improve the grade of a certificate, and to strive for certificates in other two subjects. Fortune would have it that I should be accompanied by a gentleman even more venturous than myself; this was a candidate whom I met in the railway train all the way from Aberdeen. His courage was rewarded by four first grade certificates. Last November the number was not materially altered. There were three candidates from Glasgow, including myself, another member of this Society, and a young lady who had been one of my students in a class for Animal Physiology, and in which subject she gained a first grade certificate. Physiology is a subject which ought to be taught in all girls' schools, and it is desirable that female teachers should be qualified for instructing their pupils in this eminently useful branch of knowledge. For years it has been systematically taught in a number of elementary schools, particularly the Birkbeck Schools in London, the Secular Schools in Glasgow Edinburgh, Manchester, &c., both to boys and girls, and in Heriot's Hospital in Edinburgh; but this is the most important public acknowledgment which the idea has yet met with. Miss Macomish, the lady just alluded to, had as companions other two young ladies from Birkbeck Schools in London; and these three were the first candidates of their sex for certificates in Physiology.

Should there be any very decided anxiety shown in Scotland during the course of this year to have examinations held in Edinburgh, I am in a position to say that there is a disposition entertained by the Department to meet the anxiety next November. It would be more economical to hold an examination in Edinburgh, were a suitable number of candidates forthcoming, and the objection urged regarding the great inconvenience of travelling such a distance in winter would be got rid of.

Generally speaking, it may be said that the persons most likely to work the scheme practically are the teachers of elementary schools; they form the large majority of the holders of certificates from the Department. A large portion of the remainder consists of young men completing their course of study at some of the metropolitan training

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colleges; they rarely present themselves for examination in any other subject than Inorganic Chemistry,—and, indeed, it may be said that this is the most popular subject of the whole. There were 168 persons in possession of certificates of competency to teach one or more branches of science up till November last (when about seventy fresh candidates gained certificates), and of these only a very few have cost the State anything directly for their scientific training. Here, then, is a staff of more or less competent teachers ready to hand; and this is a most important desideratum supplied.

The next point to be considered is the classes that receive the instruction. These may be either day or evening classes. Those that already exist are generally senior classes in day schools, or adult classes in mechanics' or other popular institutions. The most recent information that I am in possession of gives the number of existing science schools and classes as about eighty, including both those taught by certificated and by uncertificated teachers. There may now and then be a little "red tape" shown by the officials of the Department; but no one need be concerned regarding any interference with local arrangements. In this respect the utmost liberty is allowed. However, as the Department is responsible for the proper distribution of the money voted by Parliament for the teaching of science, it is necessary that some condition should be laid down and observed.

Wherever a class is formed on whose behalf public aid is desired, there must be a local committee, with a secretary and chairman. The duties of this committee are light, but their nature will be more evident in the sequel. Suppose a class to be formed for the study of Chemistry, the teacher proceeds to discharge his chief duty, viz., giving the desired systematic instruction, and in due time he is informed that on certain named evenings during the month of May next following, examinations will be held in all the subjects in which aid is given by the Department; the number of candidates in each subject and from each class is to be forwarded to the Department before the end of March, and when the appointed day arrives, a packet of examination papers is received per post by the local secretary. The students assemble in the examination-room at ten minutes before seven o'clock evening, and, being supplied each with pen, ink, paper, and a copy of the examination-paper, they proceed to answer the questions therein contained, under the inspection of at least three members of the local committee. At ten o'clock all papers, whether finished or not, are collected by the committee, initialed, sealed in an envelope in their presence, and posted by next day's mail to London. These papers are afterwards sent to

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the professional examiners for the Department, and as they have propounded the questions, they now proceed to award each paper its proper value.

The examiners classify the successful candidates under the following heads, in lists afterwards published by the Department:—

1. All those who have passed in each subject, the standard of attainment required being low, and only such as will justify the examiner in reporting that the instruction has been sound, and that the students have benefited by it.
2. From among those who have *passed*, those who have attained a degree of proficiency in a subject qualifying them for an honourable mention, or a first, second, or third class Queen's prize, as the case may be.
3. The six most successful candidates in each group throughout the United Kingdom, if the degree of proficiency attained be sufficiently high to warrant their being recommended for Queen's Medals.

The certificated teacher receives pecuniary payments in proportion to the success of his students in the examinations. "Payment on results" may be said to be one of the most important features in the scheme. This principle was much decried a year or two ago, in connection with the notorious "Revised Code," but no person has ever yet demonstrated it to be an unsound one. The payments are as follow:—£1 for every student of the industrial classes who has received forty lessons from the teacher in the subject in which he is certificated, and passes in such subject of scientific instruction; £2 for every one who is honourably mentioned; and £3, £4, or £5 for every one who takes a Queen's prize, according to its grade. These students must have received forty lessons at least from the teacher since the last examination at which payment was claimed on their account. The forty lessons need not necessarily be all given in one year, but may extend over a longer period. £5 is the maximum that can ever be claimed on account of the instruction of any one pupil in a subject. That is to say, for a pupil with a first class Queen's prize, for whom at a previous examination the teacher received £2 for an honourable mention, he can only claim £3. If the same pupil had previously received a third grade Queen's prize, the teacher can only claim £2 on his account, and so on.

Here, then, is a very powerful stimulus to the teacher, constantly inciting him to the proper discharge of his duty. While benefiting himself, or striving to do so, he is conferring a direct benefit on his students, for he is enabling them to secure their prizes; and again,

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the students in their efforts to gain prizes assist to increase the teachers' payments. The interests of both are mutually bound up together.

The Queen's prizes consist of valuable books, chiefly scientific, chosen by the candidates themselves from printed lists furnished for that purpose by the Department, and are unlimited in number. [A list was here submitted to the members.]

The National Medals are,—one gold, two silver, and three bronze, in each group, for competition throughout the United Kingdom. These are given in addition to the book prizes.

It was in the month of June, 1859, that the minute was passed which forms the basis of the present system of aid to scientific instruction. The first examination of candidates for certificates was held in November of the same year; but it was not until May, 1861, that the whole machinery of the system came into operation, and the first examination of science classes was held. Special examinations under the new system, however, were held in a few places before the time just mentioned; and Glasgow has the credit of being the first place to avail itself of the provisions of the scheme, inasmuch as the first class under the "Science Minute" was formed here, and the first examination held in connection therewith. The following reference to this class is quoted from a blue book, the *Eighth Annual Report of the Science and Art Department*, written by Captain Donnelly, R.E., the Inspector for Science:—"The first class I inspected and examined, which had been opened under the 'Minute,' was the science class in connection with the Glasgow Secular School. This was in June, 1860. The Glasgow Secular School does not receive aid from Government as a poor school. There are about 200 boys and girls taught in it. Science, particularly Human Physiology, had for some years formed a portion of the instruction. The head master, Mr. Mayer, came up for a certificate in Chemistry in November, 1859. He obtained a certificate of the third grade in Inorganic Chemistry, and of the second grade in Organic Chemistry. In order the better to comply with the conditions of the Science Directory, and to obtain the payments of the Department, a special science class was formed, meeting in the evenings, and consisting of the most advanced boys in the school, and also of some who, having left the school, are in employment in the town.

"Twelve boys came up for examination; two obtained first class Queen's prizes (one of these, who had left the school, was an errand-boy in a newspaper office), three obtained second class Queen's prizes, one a third class prize. Besides these, three passed satisfactorily, and

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only three failed. The examination was therefore very successful, peculiarly so, when the short time that all the arrangements, &c., had to be made in is taken into consideration."

It has been said that the full machinery of the system only came into operation in 1861. In May of that year the first examination of students in science schools and classes was held. There were 35 centres in which local committees superintended examinations. One thousand papers were worked; of these 725 were "passed," and 310 attained the standard requisite for the three grades of Queen's prizes. Some candidates worked papers in two or more subjects, so that 1,000 papers do not represent 1,000 candidates. There were about 650 individual candidates. But even this number is very great when it is considered that this scheme was then so new, and that it is the first systematic attempt to encourage the efforts of the people to obtain thorough scientific training, and to draw out the teaching power of the country and direct it into a proper channel.

This subject of teaching power is one which ought not to be overlooked in connection with any system of education, whether it be literary or scientific, or whether it be for juveniles or adults. You may appoint a person profoundly learned in any branch of knowledge to a university chair; but his extensive learning is not necessarily a guarantee of his ability to communicate his knowledge, and, by fitting language and apt illustrations, make his ideas thoroughly understood. Now, to my mind, the Science and Art Department has done well in appealing to the more intelligent teachers of elementary schools, in the confident expectation that their habits of thought and practical acquaintance with the best methods of conveying instruction would be such that the system would not only be safe in their hands, but that it would be in the very best hands possible. It is to be regretted that many teachers seem to have no ambition much beyond the merest elementary branches of instruction, and seem to think that their duties are sufficiently discharged if they limit their efforts to the teaching of these. There are, however, many worthy persons in the teaching profession, who are quite familiar with the leading principles of one or more branches of science; but the regret is that they do not avail, or have not availed themselves of their opportunities of enlarging the empire of knowledge, by assisting to raise up a larger army of inquirers and observers; and this system aims at bringing out of their comparative seclusion the class of teachers last alluded to, by offering them substantial pecuniary rewards for their labours.

It is likewise having an effect on other persons not professionally engaged in education. Already science certificates are possessed by

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several artizans, shopkeepers, mechanical draughtsmen, &c.; and doubtless they may make some valuable addition to their incomes.

I have informed you of the details of the examination of students in 1861. In May of last year the second examination was held. When the ninth Report of the Department was prepared, in January of the same year, it was calculated that about 2,000 examination papers would be given out in May, as against 1,000 in the preceding year. I regret that the classified returns of the results are not yet issued; but I am justified in stating, from what I know, that at all events upwards of 1,200 of the papers worked were "passed" satisfactorily, and that a large proportion of them were so creditable as to have attained the standard necessary for Queen's prizes. There is every prospect that the examinations in May next will bring out a still greater number of candidates.

Besides the Queen's Prizes and National Medals awarded to the successful students, there is another important feature which still requires our attention. It has been determined to grant, for the present, ten free admissions to the Government School of Mines, conferring the privileges of attending all lectures and examinations, without the payment of fees, to the most successful students at the May examinations held by the Department; and in addition to these free admissions there are at present four Royal Scholarships of £50 a-year to be held for three years. These are to be increased to ten. Here is a most important spur to young men who aim at taking eminent positions in the world of science. This school has already sent into the Geological Survey of Britain and her colonies, and into other situations requiring a scientific training, some distinguished students, and this science scheme bids fair to be so successful that there is no probability of there being any lack of such persons in a few years. A young man who, in 1861, gained the gold medals both in chemistry and animal physiology, has been appointed assistant curator of the Museum of Practical Geology, on the recommendation of Sir Roderick Murchison.

In connection with this scheme there is a fairness, an honesty, that must tell greatly in its favour. A glance at the examination papers,* either for teachers or students, shows a willingness to give the examinees every opportunity of displaying what knowledge they possess of the subjects in which they are being examined. It will be seen that in both cases the candidates for examination may make a selection of questions without the results being necessarily affected.

Possibly some of the members may already have expressed an anxiety to know if any provision is made for furnishing the means of illustration

* Examination papers in various subjects, and both for teachers and students, were submitted by Mr. Mayer for the inspection of the members of the Society.

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which are requisite for the scientific instruction. I am enabled to say, in reference to this matter, that every class taught by a certificated teacher may receive apparatus, diagrams, &c., at a reduction of 50 per cent. on the prime cost.

The present is not the time for entering upon the consideration of the question of state assistance in education. I have my own opinions on this subject, and these are so very decided that I shall be very happy to defend them at an appropriate time. When I remember that the State *does* assist science in the Royal Society and elsewhere, I have no hesitation regarding the propriety and legitimacy of the Parliamentary Vote for Science Schools and Classes.

March 11, 1863.—*The* PRESIDENT *in the Chair.*

Mr. Alfred Brown, 13 India Street, was elected a member.

Mr. Edmund Hunt exhibited some original experiments on Vision, by means of an ingenious instrument of his own contrivance.

Professor Rogers gave an explanation of the probable origin of the Petroleum of Western Pennsylvania and neighbouring districts in North America.

March 25, 1863.—*The* PRESIDENT *in the Chair.*

MR. C. GREVILLE WILLIAMS read a paper on the Chemistry of Coal-Tar Colours, illustrated by numerous experiments.

On the Chemistry of Coal-Tar Colours. By C. GREVILLE WILLIAMS, F.R.S.

THE lecturer commenced with a sketch of the researches of Unverdorben and Runge on the products of the destructive distillation of animal and vegetable matters. He also showed the results of modern researches on the same subject, and called attention to diagrams containing all the acids, bases, and hydrocarbons of coal-tar arranged in homologous series according to their chemical types.

He then showed that benzole was the starting point of the more important coal-tar colours, and gave its history from its discovery by Faraday to its production from coal-tar by Mansfield. Some of its more striking physical characters were illustrated by experiment. The steps by which aniline is obtained from benzole, and its reactions with chemical reagents were then given, and also a chronological account of aniline from its discovery to the present time. An account followed of the discovery and properties of the mauve of Mr. Perkin; and a variety

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of experiments were made indicating its principal chemical and tinctorial properties. The methods of preparing the various red colours obtained from coal-tar were also described, and their chemical and physical properties shown. The conversion of rosaniline and its salts (magenta) into blues and violets, by means of chemical reagents, was also dwelt upon and illustrated.

The lecturer then proceeded to describe the properties and modes of preparing red, blue, and yellow dyes from carbolic acid, and gave the method of preparing the latter substance in a state of purity. The manner in which the isomeric bases from coal-tar and cinchonine were demonstrated to be essentially different was also given, and the discourse concluded with some generalizations upon the chemical nature and theory of certain new bases obtained from iodide of pelamine or chinoline blue.

April 8, 1863.—ROBERT HART, Esq., *Vice-President, in the Chair.*

Mr. John Mitchell, Chemist, 34 Virginia Street, and Mr. Thomas Frame, 8 Gordon Street, were elected members.

MR. GEORGE ANDERSON read a paper on Pisciculture, illustrated by live specimens of salmon ova and newly hatched fish.

On Pisciculture. By MR. GEORGE ANDERSON.

IN bringing before this Society the subject of the following paper, viz., what has been termed the "artificial propagation" of fish, I am naturally led to touch upon the physiology of reproduction by means of ova; but that subject is of itself so extensive that I cannot attempt to treat it in an exhaustive, or even a very scientific manner. I must therefore confine myself to very general terms, merely calling the attention of members to what is an exceedingly interesting department of scientific research, opening up to an accurate observer a rich field for elucidating facts of great value both in a scientific and economic point of view; and I cannot do better than refer those who wish to enter upon the subject more scientifically, to the investigations of our distinguished member, Dr. Allen Thomson, of which, along with those of Müller, Meisner, Ransom, Davy, and others, he has given an admirable summary in the *Cyclopœdia of Anatomy and Physiology.*

The term "artificial propagation" is perhaps not a very correct one, and requires some explanation. It is not intended to convey the idea that chemical science has realized its long cherished Promethean dream

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of stealing from Heaven the secret principle of life. It does not mean that the reproductive processes of nature are altered in their essentials, but only that man extends over them such direction and control as may give him certain knowledge of the parentage and subsequent supervision of the progeny.

Such means are not only of great value to the physiologist in pursuing some of his most minute investigations, but to the student of natural history they are almost indispensable.

It is by this means alone that within the last few years that old puzzle, the natural history of the Salmon, has been step by step unravelled, till there remain only one or two points requiring further investigation. Other species are being similarly studied, and by degrees the old fables and popular errors that surround and obscure so many departments of natural history are being cleared away.

The number of such fables and fallacies connected with fishes is very great, for on account of inhabiting an element different from our own, any constant observation of their life and habits has been difficult, and therefore naturalists first turned their attention to the equally wide field presented by animals inhabiting the land, in which, of course, investigation was comparatively easy.

But strangely enough, and almost as if to compensate for the obscurity which surrounds the mature life of fishes, it turns out that in them that stage which, in all other animal life, is the most obscure of any,—viz., the embryo stage, where, in fact, any observation of the processes of nature in action is almost impossible,—receives from fish a remarkable elucidation; and thus from the depths of the waters, whence we could least expect it, a flood of light is thrown over the whole economy of embryo life, and we have a living revelation of the acting and probable universality of those laws under which Nature's wondrous work of reproduction goes on.

As a specimen of the fallacies which science has to combat even in quarters where a higher intelligence might fairly be expected, I may instance a book which was published last year for the sole purpose of proving that the parent of the silver eel is a black beetle, the illustrations showing the beetle in the act of parturition. There was also an angling work of considerable mark published within a few years, in which Mr. Thomas Tod Stoddart maintained a theory almost as absurd. It has long been perfectly well known to naturalists that the impregnation of the ova of fish is an external process, and that, under natural circumstances, it is brought about by the male fish shedding the milt over the ova as they exude from the female. Yet Mr. Stoddart devotes a long chapter of his book to proving that it is contrary

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to reason, and contrary to fact, to suppose that there can be any difference between fish and land animals in the process of impregnation, and that the attendance of the male fish at the time of spawning is not for the purpose of impregnating the ova then being deposited, but for the purpose of fecundating the next year's produce by an act of sexual coition. However, it has been long ago proved by unquestionable experiment, that when the ova leave the female they are unimpregnated, and if that process is not performed afterwards, the ova are certainly barren. When performed artificially, the following is the mode:—

By netting, a male and female fish, both in ripe condition, must be secured; they are known to be ripe by the ova and milt exuding under a gentle pressure. The female is held by the left hand grasping the back, her head towards the operator; she is held over a shallow vessel containing water, and as close to the water as possible, or even with the vent covered, so that the ova may pass into the water without the shock of a fall. As soon as the fish lies quiet, with a gentle pressure move the right hand down from the gills towards the vent, when the ova, if ripe, will flow out rapidly. The process is repeated till the fish seems empty, when she may be returned to the river uninjured. By an exactly similar manipulation, the milt of the male is caused to flow into the same vessel; after that the water is gently stirred for a few moments, and then run off and changed, separating any ova that have become white, as these are spoiled. The others are ready for depositing among gravel in running water.

It does at first sight, no doubt, appear an improbable thing, that a fish's egg, such as we see it—firm, transparent, and enclosed in a tough and apparently impervious skin—should at the mere external touch of a drop of fluid, become instantly the germ of a fresh organization, and commence that process of reproduction which ends in the hatching of a living fish; and this imperfect knowledge may have contributed to Mr. Stoddart's scepticism; but when Science threw her light upon it, Nature's beautiful economy was discovered. It was found by microscopic observation that the milt is a fluid swarming with minute spermatic zoa, creatures of a low and very simple organism, extremely small, and consisting of only a sort of head with a long filament attached, by the rapid motion of which filament the creature succeeds in reaching its destination.

By subjecting the ova to similar examination, they were found to be not quite globular, as they appear, but somewhat oval in shape, having a disc or rosette of orange-coloured globules, forming a yolk floating in the otherwise transparent contents. One side of the ovum is somewhat

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depressed, and has a funnel-shaped canal, which has been called the micropyle, opening from the outside down into the interior, where it is probably closed by the cohesion of the edges. I say *probably* closed, because, though in some varieties—stickleback, for instance—Dr. Ransom found it to be closed; in others, such as salmon and trout, it seemed open; yet, for reasons to be afterwards stated, I think there must be the means of exclusion of water in all. The outer skin, called chorion of the ovum, appears, under a high microscopic power, to be drilled through with minute pores, the object of which is not ascertained. It may be that this arrangement assists in extracting oxygen from the water for vitalizing and developing the embryo, or it is possibly for renewing all the fluids of the ovum. At the same time these pores are so minute, and the opening of the micropyle must be so arranged, that no water can pass in, for although the ova are destined to remain always in water, the introduction of that fluid to their interior destroys them, turning their albumen opaque.

At the time of deposit and impregnation a certain number of the ova become opaque, and during the period of hatching a considerable number do so; and there is reason to suppose that this is caused very often, if not always, by the admission of water through some imperfection in the closing of the micropyle, or undue disturbance, or the attacks of insects injuring the outer skin.

Müller first discovered the micropyle in examining the ova of insects, and Dr. Ransom, of Nottingham, was the first to observe it in the ova of fish; and he watched under the microscope the process of impregnation, and the changes that immediately take place in the structure of the ovum.

When the milt and the ova are brought together, some of the spermatoids find their way into the micropyle, as many as three or four having been sometimes observed in it at once; but as soon as one succeeds in forcing itself down through the orifice, and reaches the embryo cell, from that instant the ovum is fertilized, the hole closes, the ovum swells, and the canal retracts and vanishes. The spermatoid becomes the germinal centre of the future life, and round it the yolk granules form determinate arrangements, probably regulated by some sort of polarity. These arrangements of the yolk granules have been termed cleavage or segmentation. This process commences immediately after fecundation, and appears to proceed with a certain degree of geometric regularity, the number of yolk segments being successively multiplied, until a vast number of small globular masses are formed, which originate a cellular structure for the rudiments of the embryo.

In these observations on the ova of fish we have probably revealed

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to us the history of all animal generation, if, indeed, the same system does not extend to vegetable life also. But though Nature's law may be universal in its application, there are many variations in detail; for instance, the micropyle does not exist in all ova; in many the spermatic filaments contrive to enter in some other way through the chorion; others, instead of a single micropyle, have a number of smaller ones. Probably in those cases where the impregnation takes place at a very early stage, the spermatozoa can pierce the chorion; while in those cases where the ovum, for its protection, requires to have a chorion considerably indurated before impregnation, Nature provides the micropyle for the easier admission of the spermatoid; accordingly, in the ova of mammalia the micropyle has not been found, though, I believe, carefully sought for.

But while so much has been investigated and observed, the first principle remains as secret as ever,—how do the spermatozoa acquire their life? and how do they receive the impress of the parent? that low organism conveying unerringly the germ of a high organism, so that each creature shall grow after his kind, and transmit from generation to generation the most minute characteristics of the parents. Truly, we follow Nature in her most secret workings, but some of her mysteries seem beyond our ken; yet after what has been done, who shall say that even in this direction the bounds of human attainment have been reached?

The subsequent history of the embryo is comparatively well known: its development goes on till the young fish can be seen lying coiled up in the ovum, its tail often in rapid motion, and its eyes most distinctly visible. The creature grows in strength till at last its exertions to uncoil itself overcome the tenacity of the chorion, which splits and liberates its occupant.

But though it is now a living fish, able to swim in its native element, it has not quite passed from the phase of embryo life. Its apparatus for breathing and that for feeding are neither of them developed; and the sole instinct of its life is to find safety from enemies, for which purpose it hides down among the gravel, and moves about but little unless disturbed.

When the chorion split and liberated the young fish, it appeared that there was an inner membrane, enclosing what remained of the yolk and other fluids of the ovum; this bag of fluids remaining attached under the young fish. This umbilical bag contains not only the nutriment of the embryo, but seems to perform the functions of lungs by means of the blood vessels on its surface, where the blood comes to be oxygenized, and it likewise contains the whole digestive apparatus.

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The fluids are probably renewed and supplemented from the external water, by pores or otherwise, for the young fish with its bag almost immediately exceed the size of the ovum that contained them both, and the absorption is a slow process, in the case of the salmon lasting about six weeks. As the absorption goes on the bag is drawn inwards till it contracts into its future position as the belly of the fish. In the meantime the heart has been throwing out new blood vessels in loops on each side, from which the gills are formed, and the creature has been learning the use of its mouth, and is now a perfect fish, breathing by its gills, freed from the encumbrance of the bag, and able to move about in search of its food.

The specimens exhibited are young salmon, now from three to four weeks old. They were sent to me from Stormontfield by Mr. Brown, of Perth, shortly before hatching.

This year at Stormont the period from the impregnation of the ova to their hatching has been 115 days; the period varies in different years, having been as low as 108 days and as high as 160; and it is still uncertain whether, by lowering the temperature still further, the time might not be protracted beyond that, if transporting them on a long voyage should render that desirable. By moderating the temperature the time can be very much accelerated, for I have myself hatched salmon ova in the house in 63 days, and I think Shaw speaks of having done it in 60.

The variation depends mainly, but not entirely on temperature; the slow or rapid run of the water, giving less or greater supply of oxygen, makes a material difference; the quantity of light, and probably other circumstances, also affect them. I have known ova take nearly twice as long to hatch as others, merely from being placed in a deeper and stiller part of the same stream.

The subsequent history of the young salmon is as follows:—As the little creature begins to feed and to gain solidity, his colours appear, and he acquires the red spots of the trout, as well as those cloudy finger marks down the sides which establish him a "parr." All the salmonidæ, salmon, bull-trout, sea-trout, river and lake-trout, grayling (and probably charr and smelts also, though I do not *know* of these), have in their youth these parr marks more or less vivid, and greatly varying in vividness in different individuals of the same species. Thus there has been, and necessarily will be, great confusion as to the definition of a parr, or in knowing to what species any given specimen really belongs, unless where the breeding has been under supervision; and endless have been the dissertations and arguments, involving even legal rights and penal prosecutions, on the abstruse question, "What is the parr?"

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which can be answered only by saying that the parr is the young of any of the salmonidæ.

The salmon parr remains in fresh water, and goes on growing moderately for a year, by which time he varies from three to five inches long. At that age a large proportion, probably about half, become mature for their first journey to the sea. At the time of this change, which is mostly in May, the fish becomes fat, soft, and loose in his tissues, and is very easily injured, his spotted and flecked coat becomes covered over with an outer dress of bright silvery scales, entirely hiding the parr marks. He is now a smoult, and in putting on the smoult dress he has acquired the migratory instinct, and at once commences his restless journey to the sea. But the period of life at which this change to smoult occurs varies so much in different individuals, that while about half the hatching become smoults at one year old, nearly the other half remain unchanged till two years old, and some few even delay their change beyond that. This and other seeming anomalies in the history of the salmon are probably wise arrangements of Nature for equalizing the crop, and for counteracting the effects of those years when, through floods or frosts, the hatching has been a failure.

The young fish that do not become smoults at one or at two years old are only exceptional, and it is still uncertain if they become smoults at three years, or if they are only the weeds of the family, that thrive at no age, but pine and die off; but I believe I have now the means of settling that point, as I have at present in a pond in Renfrewshire the few two-year-olds that remained as parr in the Stormont pond last summer, when all that had become smoults were gone, and when the pond had to be cleared out for the new hatching. They were mostly small and ill thriven, and some have died off during the winter; but I shall watch the rest about May with much interest, to see what they turn to. Even if they become smoults I mean to retain them in confinement, to test the disputed point maintained by M. Costé, that they may grow to salmon, and even breed without going to sea at all.

Of the smoults that go down to the sea in May and June, whether they are of one year old or of two years old, undoubtedly many return to the rivers as grilse in a very few months, but there is no certainty that they all return the same year, and if any delay their return to the following year, it is not known in what form they then come, whether as grilse or as full-grown salmon. In other words, it is uncertain whether the fish can pass through its grilsehood in the sea, or if it remains a grilse till it revisits the fresh water. The point, however, is not of great importance.

There are other anomalies or exceptional cases unaccounted for, and

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altogether the natural history of the salmon is a very interesting study, from its many variations. Perhaps its most remarkable features are, the instinct which prompts it to diffuse itself over the whole interior of a country, wherever there is a stream to penetrate by, and in the face of obstacles that appear insurmountable. Then there is Nature's wise provision against barrenness, in allowing the male parr to ripen its milt and to fecundate the ova of the full-grown salmon, so that if the female should penetrate to a place where there is no male, or if her mate should chance to perish, her ova will not be lost, for there are always parr ready for her.

Then there is the remarkable rapidity of growth, and the contrast of growth in different individuals of the same age. Thus we have the smoult of a year old going down to the sea when hardly weighing two ounces, and returning in a few months, and when only fifteen to eighteen months old, a grilse of three to five pounds. It breeds as a grilse, returns to sea as a kelt at two years old, and returns from the sea in three to six months more, a full salmon of eight to fifteen pounds, while many of its brothers and sisters of the same hatching and same parentage are still only smoults, or, perhaps, only parr of a few inches long. No law has been discovered regulating this remarkable variation, which seems to depend on mere accident of feeding or development.

On the general subject of fish-culture we, in this country, appear to be very ignorant, or very careless. Raising fish for the food of the people, and as an article of profit, is entirely unknown or unpractised. Why the proprietors of rivers and lakes have been so long of turning their attention to the subject I cannot explain, unless it be that they are too well off without it, and are not driven to develop to the utmost the resources of their properties; but I am of opinion that when the subject is more generally understood, every lake and river in the country will be treated as "a fish farm."

China, with its curiously old and unprogressive civilization, fully comprehends the value of fish-culture, for she has been driven by the necessities of her dense population to develop, in an extraordinary degree, all resources of feeding. On the Continent some attention has long been paid to it, and of late years France has been making large efforts in that direction.

The process of manipulation above described was known in this country and on the Continent nearly a century ago; but we find no record of its being turned to any account, except for purely scientific purposes, such as the experiments of Jacobi, Shaw, and others. But about twenty years ago two French peasants, named Gehin and Remy,

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used it successfully for increasing the quantity of fish in some of the rivers of France. The French Government, always alive to such matters, immediately took it up, and have extended the scheme and encouraged it liberally. They have now a large establishment at Huningue, on the Rhine, where they treat many varieties of fish, and give off annually large supplies of the most valuable known kinds for stocking the rivers and lakes of France, and are besides experimenting in acclimatizing foreign varieties. The French are likewise successfully planting oyster beds all round their coasts. This department is under charge of M. Costé, who was among the earliest French experimenters in salmon and other fish. The mode of colonizing the oyster is very simple. The seed is got by sinking faggots where oysters are known to be. The seed is given off by the oysters in immense quantity, and anything to which it can attach is covered. These faggots are then taken up and conveyed to any suitable place for forming a bed, and sunk there; and from such a beginning, if suitable holding ground for oysters exists naturally, or can be arranged, a very few years is enough for the establishment of a profitable bed.

In that branch also we have done nothing, yet there is no reason why we should not; and no reason that I know of why we should not acclimatize the American oyster, which is a different fish, and a finer one than our own.

The attempts at fish culture in our own country have been few,—about nine years ago the pond at Stormontfield, near Perth, was established for aiding in restocking the Tay. Though considerable success has attended it, unfortunately it has been managed with the most grudging parsimony, and although so small an additional outlay as the making of an extra pond would at once just double its productiveness (for with one pond they can only hatch every second year), and make it really a valuable nursery for the river, everything remains on the original limited scale, and even the present arrangements are going to decay. Many of the boxes had to be left unstocked this year because the wood had got rotten. Let us, however, give the Stormont establishment the credit it really deserves for having done so much to solve the natural history of the salmon.

Messrs. Ashworth, of Galway, have a much larger establishment of the kind, managed on very different principles, and, I believe, with great success. These gentlemen are extremely liberal in giving ova to assist similar establishments elsewhere,—a liberality which also characterizes the Huningue establishment managed by M. Coumes, while our Tay proprietors refuse everything.

In 1855 the West of Scotland Angling Club arranged a small estab-

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lishment at Abington, on the Clyde, for the purpose of acclimatizing the grayling in Scotland. Probably this was the first occasion on which the system of artificial breeding had ever been used for colonizing a country with new fish, and so far as I am aware, the first on which it had ever been attempted to transport impregnated ova from a great distance and then hatch them. A new system of transporting live fish was also originated by that experiment, and has proved very successful, as did the hatching of the ova also, and in consequence, the grayling, a fish highly esteemed in England, but previously unknown in Scotland, is now abundant in the Clyde, and spreading to many others of our Scottish streams.

Several attempts have been made of late years to transport salmon ova to Australia, but in every case either weather difficulty or the omission of some important provision in the arrangements has baffled the attempt; but I see no reason to doubt its ultimate success, provided proper arrangements are made for the reception of the ova in a suitable locality out there.

Last year the Thames Preservation Society arranged a small breeding establishment at Hampton for supplying the Thames with salmon, trout, and grayling, and this year they have added several foreign varieties; but none of the establishments in this country, except Messrs. Ashworth's, are on a scale sufficient to produce great results, or indeed to have any commercial value at all.

The great advantage of nurseries for breeding and rearing fish is that, in their natural state, both the ova and the young fish are the prey of countless enemies, birds, fish, and insects, and the victims of constant accident from drought, flood, and frost, from all of which hazards artificial rearing almost exempts them. In order to have a large stock of fish, however, in a general way artificial feeding must follow artificial rearing, for without that, of course, lake and river can only contain the limited quantity of fish for which there is natural feeding. But the salmon is a valuable exception to this rule, and herein lies the superior advantage of salmon culture over every other. If only they are reared and fed till they reach the smoult stage, nothing more requires to be done; there is hardly a limit to the quantity of salmon a river might contain, for they feed little in fresh water, and all their richness and growth is gained in the sea; out of which they emerge voluntarily, as if for the very purpose of conveying the wealth of the deep to the farthest corners of the land for the use and delight of man.

In aiding this wise and bountiful provision of Nature, as well as in establishing other branches of fish culture, I believe there is a large field open for energetic enterprise; that by these means the food-pro-

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ducing power of the country can be increased, the comfort of the people augmented, and a new source of individual profit and of national wealth opened up, that has been hitherto undeveloped and unknown.

April 22, 1863.—*The closing Meeting of the Session was held this evening, the* President *in the Chair.*

The Rev. Francis P. Flemyng, Glenfeulan, Shandon, and Mr. Edward Wünsch, Merchant, 149 West George Street, were elected members.

Dr. Bryce gave an account of the Lochwinnoch Copper Mines.

The Rev. Henry W. Crosskey read a paper on the recent discovery of the remains of a Cetacean in the banks of the river Irvine.

On the Recent Discovery of the Remains of a Cetacean in the Banks of the River Irvine. By the Rev. Henry W. Crosskey.

The general characteristics of the country near Irvine are well known. A fine sand, similar to that now edging the sea, has been deposited and drifted inland to a considerable distance, rising in a succession of slightly elevated knolls. Near the shore these knolls are more distinctly marked, being more recently formed, and their loose material not having been driven over the dividing gaps. More inland their divisions have been to a great extent obliterated, but excavations show the sand rising and falling at different heights, exactly as in the line of hillocks now fronting the sea.

Following the Irvine Water at about two miles from the sea, we reach a fine section of clay and sand cut out by a curve of the stream.

I. The base of the section is the boulder clay, of the true normal type. The boulders, chiefly of trap and limestone, are not very far travelled, and are beautifully striated. As usual, this boulder clay has sharp undulations, and dips violently within short distances, rising nearly to the surface in one direction, and then passing down beneath the stream, a variation of 20 feet within a quarter of a mile.

II. The boulder clay is capped occasionally, but not persistently, along the line of its outcropping, with a few feet of ferruginous gravel. This gravel, as well as the boulder clay, has been acted upon by some great denuding power, and occurs simply in patches. It may be recognized in good sections of the glacial series of beds, as at Lochgilphead, where it rests upon the deposit of arctic fauna, but probably

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shifts with local circumstances, and is not a distinct and consistent term of the series.

III. Here occurs a vast gap in the normal arrangement of the strata. The boulder clay should be followed (according to the local order, which may now be considered as established for the Clyde beds) by the highly laminated, unfossiliferous clay; that again by sands and clays containing an abundant arctic fauna, and succeeded by a clay less laminated than the preceding, but like it entirely unfossiliferous. Of this wonderful period, during which myriads of the *Pecten Islandicus, Mya uddevallensis, Leda oblonga, Tellina proxima*, occupied our waters, there is no record in the Irvine section.

IV. Following a slight layer of peat, an inch or two in thickness, but which only appears at intervals, comes the first great shell bed in the section. At the point described the boulder clay is hollowed out and has disappeared beneath the stream. The old clay has evidently been disintegrated and its boulders rolled upon a beach. The small boulders scattered about are of the same material as those in the older bed, but their striations are gone, and they have evidently been submitted to the rolling action of the waves.

Among the shells imbedded in this old sea-bottom, not a single arctic form could be detected; and among hundreds and even thousands of scattered valves, not even a broken hinge could be seen of the abundant fauna of the immediately preceding period. Although resting upon the boulder clay itself, and 20 feet beneath the surface, there is no sign that this bed contains a transitional fauna, occupying a middle position between existing and arctic conditions.

Although the valves of the specimens are generally loose and separate, yet several perfect examples were extracted, proving that it is not a mere drift bed, but that many of the various molluscs lived and died upon the spot. The action of the Irvine Water, often rising to great heights, would be amply sufficient to break up the shells and scatter them on its banks. From the bed of the stream, however, a fine example of *Mactra stultorum* was obtained *in situ*.

V. Upon this rough sea-bottom, with its stones rolled out from the disintegrated boulder clay, rests the fine sand of the district.

In this sand, 14 feet from the surface, and about 4 feet above the usual level of the stream (which, however, greatly varies according to the season), Mr. Hugh Jack, farmer, of Shewalton, observed a large bone protruding, measuring 6 feet across, and weighing upwards of 2 cwt.

Photographs of this specimen are now submitted to the Society, which have been kindly examined by Professor Allen Thomson, and

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declared to include a considerable portion of the occipital bone, with the condyles, foramen magnum, and pterygoid processes of a large cetacean. Upon visiting the section, I was fortunate enough to extract another specimen of apparently the same animal, and now exhibit the bone from its left ear in a remarkably fine state of preservation.

VI. The same fine sand continues to the surface, but is broken by a second shell bed, nearly 2 feet in depth, and extending along the section in a regular and persistent line.

Of this shell bed it may be remarked, that it must have been deposited after the cetacean stranded in the hollow of the boulder clay, since it is unbroken in regularity, and has not been disturbed subsequently to its deposition. It is probably contemporaneous with the cardium edule bed of the following section taken at Paisley:—

1. Alluvial soil, 4 feet.
2. Littoral shell bed, 9 inches (*Cardium edule* in abundance.)
3. Unfossiliferous clay, 6 feet.
4. Fossiliferous clay (arctic species.)

The shells have not altogether been heaped up as a drift caused by wind and tide, since many perfect specimens, fresh as when they were interred, can be obtained from the bed. *Tellina tenuis* was extracted with both valves entire, together with numerous perfect examples of *Mactra subtruncata*.

This second shell deposit also appears to indicate a less depth of water than the preceding. Its contents consist of species such as *M. subtruncata*, *T. tenuis*, whose special habitat is the sand in shallow water; while from the lower bed were obtained *Cyprina Islandica*, *Lutraria elliptica*, which range to slightly greater average depths.

The rough stones of the lower bed have, it would seem, given place to the finer sands, and the waters have become more shallow through the gradual uplifting of the land, the nature of the characteristic fauna becoming slightly changed during the process.

To sum up the contents of this section:—In the first place, the striated boulders at the base speak of ice grinding and polishing. We know from other sections that subsequently an arctic fauna inhabited the region, but its record has vanished from this spot. The clay was hollowed out; gravels accumulated, and were swept away. A fauna passed, and left no sign of its presence.

Subsequently, the stones of the older clay were rolled, and their striations worn away, and an abundant fauna lived, every species being the same as in our existing sea.

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The land was evidently rising. Fine sands show the shallower shore, while a wandering whale finds deep water no more, and strands and perishes.

The sands still accumulate. The shore is altered. The boulders are covered deeper and deeper, and the tellina and mactra live and die within the sands which gather over the stranded cetacean at Irvine, and spread themselves into a cockle bed at Paisley.

The land still rose, and sands continued to be deposited, until now two miles inland, 14 feet beneath the surface, and 20 feet above the sea-level, these bones and shells remain records of a past during which every existing animal flourished in the waters, but whose sea has become the dry land of to-day.

The following species were collected from the section:—

Artemis exoleta.
,, lincta.
Cyprina Islandica.
Cardium edule.
,, norvegicum.
,, echinatum.
Lutraria elliptica.
Litorina rudis.
,, litorea.
,, litoralis.
Mytilus edulis.
Mactra subtruncata.
,, stultorum.
Natica monilifera.
,, alderi.
Nassa reticulata.
Ostrea edulis.
Pecten maximus.
,, opercularis.
Patella vulgata.
Purpura lapillus.
Solen siliqua.
Trochus magus.
,, cinerarius.
Tapes decussata.
,, pullastra.
Thracia phaseolina.
Tellina tenuis.
Venus striatula.

Mr. James Russell read a paper on the Tertiary Coal of Borneo, Sarawak, illustrated by maps, sections, and specimens of minerals and fossils.

On the Tertiary Coal of Borneo, Sarawak. With a Section.
By Mr. James Russell, Mineral Surveyor.

In August, 1856, I entered into an engagement with that honourable and enterprising Company, the Borneo (Limited), to serve them as exploring mining-engineer in the sovereignty of Sarawak, island of Borneo. They had leased the coal and other minerals from that great and good man, Sir James Brooke, Rajah of Sarawak, who had been in possession of it some twenty years previous to my engagement. The coal was already being worked. The sago trade and other branches

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of commerce had been opened up long before I went out, by the enterprising director of the Company, Mr. Harvey, of Messrs. Morgan & M'Ewen of this city, and then resident at Singapore.

At the time of my arrival at Sarawak there were resident there thirty-four European adults—nine of whom were females, and thirteen belonged to the Rajah's government. He had no standing army, and ruled about 30,000 Chinese, about 40,000 Malays, and about 85,000 Dyaks, in all, about 155,000 subjects, inhabiting about 12,000 square miles of territory. The Bishop of Labuan had a mission station in connection with the Church of England, whose staff consisted of himself and lady, three missionaries, a schoolmaster and schoolmistress, and another female, who looked after the cooking, washing, mending, and other comforts of the children attending school. The Company had an agent, Mr. Helms, at Sarawak, manufacturing sago, buying antimony, bees'-wax, gutta percha, and other native products of commerce, from the Chinese, Malays, and Dyaks. Mr. Coulson and two assistants were opening up a coal mine at Simunjen, and preparing to make three miles of a railway from the mine to the junction of the river Simunjen with the Sadong, where ships could be loaded. There was another European gentleman, Mr. Rupell, a merchant, said to be in company with some of the Chinese.

The country of Sarawak is flat and swampy near the coast and borders of the rivers; and where the schist forms the surface there are little undulating hills of porphyry, and occasional isolated hills, with water and swampy jungle surrounding them. Various species of palms and other trees abound, which, together with the green underwood, give the country a beautiful and picturesque appearance.

The section produced is intended to show the different geological deposits, and their positions relative to each other, with the injected igneous rocks as they appear in the various strata; also, the external weathered outline as seen in knolls, hills, and plains.

The igneous veins in the limestone represent those seen at Bidi and Bousoe. The veins shown in the schist occur at Cape Datu, and between Bidi and Gumbong. The red and yellow sandstones and their veins appear at Santubong and Mount Linga. The large mass of igneous rock in the section is at Mount Linga. The coal and its igneous veins and overlying mounds are represented as seen at Simunjen-neck, and at Balow and Klingkong. The red sandstone above the coal appears at Klingkong and Lanje. A great many kinds of igneous rocks penetrate these strata, altering and contorting them; but to attempt to arrange them in a section like the present would only tend

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to confuse. Specimens of the rocks are produced, with their names and sources stated.

The limestones are the lowest deposits I have seen in the country. They underlie a great deposit of clay, siliceous schists, and thin sandstones. They are generally much disturbed by igneous injections, vertically, obliquely, and horizontally. These igneous rocks have been the agents in elevating the limestone, forming hills from 300 to 800 feet high. The clay schist also appears in little hills near the outcrop, but they are of inferior magnitude, the highest of them not being over 300 feet, while the average may be less than 100 feet. They are round and flat topped, and have a very different appearance from the limestone hills, the latter consisting of rough projecting crags and spurs, fluted with groups of spiral columns, and the surface showing the great loss sustained from the effects of time and weather. The limestone in general has this appearance more or less wherever I have seen it in great masses; and the abrading of the surface is in great measure due to the Bornean rains, which fall very copiously. The limestone under the surface shows great crevices, some of them thirty-six feet deep, sixty feet in length, and from one foot to twelve feet in width. These occur a few feet above the level of the river; but in the hills there are huge caverns caused by the decomposition of the igneous rocks perforating the limestone. The igneous rocks contain iron pyrites, with a little gold, and seem to have decomposed more readily than the limestone. It is in these caves where the best edible birds' nests are obtained. In the same caves I have measured columns of stalactite rising 105 feet 7 inches from the floor to the roof, and 12 feet in circumference. Some of the cave chambers are 80 feet wide by 325 feet long, narrowing at each end, and so lofty that I was unable to measure their height. There are some considerable lakes in the caves, with rivulets flowing from them. The largest piece of gold that I saw in the country was got from one of these caves.

The general rise of all the strata is towards the limestone hills. The schist crops out, and rises at a very high angle—from 45° to 80°—at the base of these hills. The schist rises to and dips from them in every direction. There are other hills associated with them, which are as high, and sometimes higher; they may be described as a species of porphyry, sending out dykes and veins, and forming a series of lesser hills and knolls, from 10 feet to 800 feet high. Antimony, arsenic, and gold are always obtained at favourable junctions of these three descriptions of rock, and occasionally copper. Diamonds are also found amongst the clay and sand at their base. A hot spring issues from one of the dykes or veins of igneous rock in the Bousoe district. The

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antimony is generally mixed with porphyry rock, but pure and good antimony is met with in the limestone and schist, which form the matrix. The antimony occurs in round and in wedge-shaped masses, the igneous crust having decomposed, leaving the pure ore. The porphyry at Quop is very like the last-described igneous rock. The hills composed of it run in a line along the west side and close to the limestone, stretching from Quop to Gumbong. Viewed at a distance, their summits much resemble those of the Cuchullin Hills of Skye.

Bidi, Bow, and Bousoe are the three important antimony and gold districts at the limestone hills. From Bow to the mouth of the Sarawak river—the distance being about fifty miles—the strata consist of schist, fire-clay, and thin bands of sandstone, and having occasionally fossil plants and mere traces of coal, with igneous rocks, forming dykes and mounds. There are three little hills near to Sarawak, and not far from the banks of the river, with a few feet of the undermost limb of the sandstone on their tops, overlying the schist. There is a little white quartz hill at the Martabas mouth of the river, and at a junction of the sandstone and schist. Tanjong-Po, Santubong (2,700 feet high), Matang (3,168 feet high), and Singi are composed of sandstone resting on schist and igneous rock. These hills, with a few small ones, may be called outliers; the first three have curious bent conical sandstone columns at their summits. The Island of Sampadien has, on the west part, a few fathoms of the lowest of these sandstone beds resting on schist and igneous rock; the remainder is composed of schist and igneous rock alone. Gading, or Mount Brooke, is formed of granite, with schist around its base. Poy is also composed of granite, with schist around its base, turned up on edge; this mountain is upwards of 6,000 feet high. Cape Datu is formed of granite, overlying schist, which is metamorphosed;—some of it is converted into slate, where it is in immediate contact with the granite, and where the action of the heat has been most intense; but towards Samatan it has not been so much affected by it. At the mouth of the river Samatan there is a young deposit of sandstone rock containing fossil shells; it is covered with loose white sand, and overlies a thick bed of clay, which contains plants. The clay is not consolidated like the sandstone, and is acted upon by the tides, which undermine the sandstone, causing it to fall over in large blocks from nine feet to twelve feet thick. The island of Talang-talang—famous for turtle eggs—is composed of granite and syenite, with quartz veins. The island of Satang-large is composed of schist and granite, with porphyritic veins containing a little copper. The island of Satang-little consists of schist metamorphosed, and porphyry

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with pyrites of iron and nickel. A report was current of a four feet coal on edge being found in the swamp, about two miles west of the village of Santubong. Mr. Dugud, who came out shortly after me, to be resident director, sent me to examine it. There is a little inlet of the river at the place of the reported coal, which, when I went to it, was covered by the tide to a depth of three feet of water. I had a pick, and cut some of the coal, for it really was coal; but when the tide had fully ebbed I found this coal to be a large tree which had been changed into coal; the exposed part was forty-eight feet long, with very little taper; the remainder was covered with the mud; but by digging out the mud under a part of it the circumference was found to be eighteen feet; more than a fourth of the upper part was worn or washed away by the tide, the rings of the tree resembling seams of coal, which had deceived the gentleman who had reported it as a coal on edge. I found many trees similar to this in the same bed at this part of the swamp, some of which were changed wholly into coal, and others partly into coal and partly into lignite. The fruit of the Nepa-palm, with other fruits and pieces of wood, were also converted into coal and lignite. A few yards farther in the swamp from where the first tree was got there was a black and brown sandstone stratum, with clay-shale beds, and about eighteen feet in thickness, overlying this young coal bed. Here I found a regular deposit of trees, fruit, vegetable remains, and shells; and I considered that, at one time, the tree first observed had likewise been covered by these sandstones and shales, and subsequently laid bare by the washing of the tide. In this part of the swamp the stench was sickening and unbearable.

Near the mouth of the Sadong river there is a little island of sandstone which underlies the coal. About fifteen miles up the river, where it is joined by the Simunjen river, there is a little hill, two miles inland, called Sidolo; it is composed of red and white quartz, with red sandstone at the base, so that the Sadong must flow about thirteen miles over red sandstone before coming to the undermost coal. About five miles from this hill and three miles from the junction is the mountain Gnili, where the Bornean Company opened up a coal mine and made a railway. The coal looked well at the crop-out along the face of the mountain, measuring from three feet to six feet thick, with three partings of fire-clay; but in working out the coal the fire-clay thickened and the coal got thin and irregular. The coal thus ceased to be profitable, and the Company stopped working it. There is another coal overlying this one about fifty-five fathoms; it is from two feet to two feet three inches thick, good and clean. Trap rock comes in contact with it about two miles south from the working mine, where it is

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partially an anthracite. There are a great many thin coals on this mountain, but none of a workable thickness.

At the mouth of the river Lupar the country is crossed by a chain of granite hills, about 500 feet high, and called the Bliong hills: they terminate on the west bank of the river. There is also a small hill in the centre of the river. All these hills obtrude through the red sandstone, which appears at their base. Towards Mount Linga red sandstone appears, along with part of the under limb of the coal. Mount Linga is wholly formed of red sandstone, resting on granite. I have measured here 500 fathoms of sandstone without any traces of coal, but saw trunks of fossil trees. This hill shows a vertical face of 400 feet all round, with no way of access to the top but by climbing up a water course. The Linga branch of the Lupar river flows from its source in the Klingkong hills, near the base of Mount Linga, over a distance of sixteen miles, through coal beds, shales, fire-clays, sandstones, and thin clay ironstones. The undermost of these coals varies from sixteen inches to twenty-two inches: it is a good bituminous coal. For fifty fathoms above this coal the strata are shale, fire-clay, and sandstone. There is another good bituminous coal, varying in thickness from two and a-half feet to three feet two inches. At Linga it is changed into anthracite by granite, and is four feet thick. For about 100 fathoms above this last coal the strata are composed of thin coals, fire-clays, shales, and sandstones; and here there is another good bituminous coal, with from two to four divisions or partings in it. The coal varies in thickness from four and a-half feet to six and a-half feet. On the side of the Klingkong range I have seen two miles of this coal's outcrop: it is very regular here. For about seventy-five fathoms above this thick coal the strata are thin beds of coal, interstratified with greenstone and other igneous rocks, which have burned the coal where in contact with it. Some of the specimens produced illustrate these effects. There are also beds and bands of bituminous shale, clay shale, fire-clay, and clay ironstone, accompanied by sandstone. There is here a good and bituminous coal two feet thick. For about seventy-five fathoms above this two-feet coal the strata consist of thin coals, bituminous shales, clay shales, fire-clays, and ironstone balls and bands: the two thickest of these coals are respectively sixteen inches and twenty-two inches; they are covered with shale-beds containing some shells. These shell-beds and thin coals are covered with about 130 fathoms of red and white sandstones, from fine-grained to a large conglomerate, with no fossil shells: plants are very rare in them. The fossil shells at Balow, Mongo, Simunjen-neck, five miles south from Simunjen coal mine, and at Lanje, are in the same position. Wherever

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I have found the fossil shells I have found the coals under them, with their shales containing plants. The plants are also very regular. I found out by these shells and plant-beds, and other characters of these strata, where to get the coals when they are covered by the alluvium. Wherever I got these shells I was sure to get the coals, and *vice versa,* where there was thickness of strata to show them both. This coal-field covers an area sixty miles long by an average of twenty miles broad. I consider there will be at least 600 square miles of Rajah Brooke's territory containing these thick coals; and the thin coals sometimes thicken from six inches to three feet in their course through the basin. There is a coal at Scarow only six inches in thickness, while at Lanje, in the same position, it is three feet thick.

When I first went to Borneo the general appearance of the coal seemed to me to be the same as that of this country, having a great thickness of reddish sandstones on the top, and a great thickness of red sandstones under it, and again, under this, a great thickness of schist, with thin bands of sandstone, schist, and limestones. These last are rich in fossils, but on examining the plants in the coal district I found them to be tertiary; and as I thought the coal rested on old red sandstone, and this, again, on Silurian—many of the fossils having a great resemblance to those of the Silurian system—I brought home a few fossils from the different formations and submitted them to the inspection of eminent geological friends in London, Edinburgh, and Glasgow. None of them, however, have as yet given me a distinct definition of them, except Sir Roderick Murchison and Mr. Salter, to whom I showed two small specimens of limestone fossils, and part of a plant (now on the table). The moment they saw them they pronounced them all to be tertiary fossils, although they were mere fragments. I felt myself very small when I heard that the limestone fossils also were tertiary. This was the most remarkable instance of geological sagacity I had ever seen in all my experience, and the best hint I ever received as to the importance of my studying Geology and Palæontology more than I had hitherto done. I have now no doubt of these being all tertiary fossils. I may mention in connection with this that the only fossils which bore any resemblance to our coal plants were two from the schist, one got at Sarebas, like Stigmaria, and one at Sinawan, like the stem of a Sigillaria; both are in the Company's collection at Sarawak.

The course of the river Sarebas is nearly all through schistose and igneous rocks, which, in decomposing, form fine white clays and hydrous oxide of iron. The natives were accustomed to make their implements of war from this ore; but since the country came into the

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possession of Rajah Brooke, European iron has been introduced as an article of commerce, and they have ceased to use the native metal. This part of the country is hilly and undulating, with very little jungle, not unlike some of our upland districts in Scotland; it is thickly populated and well cultivated; the natives grow their own cotton and make their own cloth, being very industrious, but, withal, very fond of *human heads.*

The Sakarran Dyaks are similar to these Sareban Dyaks, but more noble and gentlemanly—if I may say so—in all their habits, although they also have a *penchant* for human heads. The Balow-Hill, the Sow Dyaks, and the other Hill Dyaks resemble each other in their habits, but are not quite so addicted to the accumulation of skulls as the Sareban and Sakarran Dyaks. They are all spirit-worshippers; and they believe that the number of slaves they will possess in the next world will be equal to the number of skulls which they collect in the present. The Bishop of Labuan and his missionaries have made a great many converts to Christianity among the Dyaks and the Chinese, but few, if any, among the genuine Malays. Mission work in Borneo is very laborious, requiring much ability, energy, and patience. The Bishop of Labuan seems to me to possess all the requirements of a successful Bornean missionary. These Dyaks manufacture mats of various kinds for their own use and for sale; they hunt, fish, cultivate a little rice, and gather in orchard and wild fruits and roots of the country. Every river teems with fish of various kinds. Every district abounds with large trees called Tapangs, from 150 feet to 300 feet high, on which the bees construct their hives: when the honey is ready, the natives ascend by ladders of bamboo, smoke the bees, and remove the honey and wax. Wild pigs are in abundance: there are three kinds of deer hunted by the natives. The people know nothing of medicine; and when any one is sick, they ascribe it to a devil, and sing, chant, drum, and make a noise, to frighten it away. No very dangerous quadrupeds exist in Borneo: a small black bear with white breast, and a small tiger-cat, are dreaded by some of the natives, but these animals are not dangerous. There are many different kinds of monkeys; a brown one with a long nose, and the ourang-outang, being the only large species. I never saw either of these animals far beyond the boundaries of the out-crop of the coal. I have seen a great many of the latter (the ourang), having lived some time in that part of the jungle which they frequent; but this paper will not admit of any details about them. Snakes of various kinds are plentiful, and these are the only animals I dreaded in that country. The crocodiles or alligators are of frequent occurrence in the rivers. Air-plants, pitcher-plants, rhodo-

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dendrons, tree-ferns, and many magnificent flowering plants are seen. Butterflies and beetles are abundant, and of great beauty. Pheasants, partridges, water-crows, and king-fishers of gorgeous plumage are occasionally seen, but in no great numbers. What are termed flying foxes, flying squirrels, flying sloths, and flying lizards, I have observed in different districts. Wild pigeons and snipes occur, very like the species in this country, but the pigeons are larger.

In the absence of Mr. James Young, of Bathgate, Mr. Napier, Chemist, described a new Pyrometer.

The President, in intimating the close of the Session, congratulated the Society on the interest and practical importance of the proceedings during the past winter, and expressed a hope that the members would prosecute their pursuits in the summer months with a view to bringing the results of their investigations before the Society in the following Session.

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PROCEEDINGS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW.

SIXTY-SECOND SESSION.

I.—*History of the Invention of the Optical Illusion called the "Ghost."* By Dr. John Taylor.

Read November 18, 1863.

For a number of years past, I have been engaged in experiments with a view of giving to transparent photographs on glass the quality of changing their effects and aspects as dioramic pictures. One of the methods adopted consists of a revolving cylinder of paper or calico, tinted of different hues and shades, and placed behind the picture so as, when seen through the sky and the transparent parts, to give corresponding changes to the colour and light and shade of the view. The apparatus and its effects have been at different times described in the photographic journals, and need not be here further alluded to than by mentioning, that in attempting to get all the charm and variety of change which can be given to the *ordinary* dioramic pictures, the transparency of the photograph on glass presented a difficulty, which will be at once understood by considering that in the ordinary picture the introduction of the sun or moon, or the appearance and disappearance of figures, or the change from a summer to a winter aspect, is made by showing the scene first by a front light, and afterwards by transmitted light, the figures, &c., being painted on the back of the picture, and only brought into view when light is allowed to traverse the canvas. As the *photograph* can only be seen by transmitted light, this artifice cannot be resorted to. After many experiments it occurred to me that the appearance of the sun and moon, or of figures, might be introduced into the picture by *reflection* from a glass plate placed between the picture and the spectator. I accordingly placed a transparent plate of glass, of about seven square feet in surface, in front of the photograph, and inclined at such an angle that any object placed in a convenient position above the picture, and in front of it, might be

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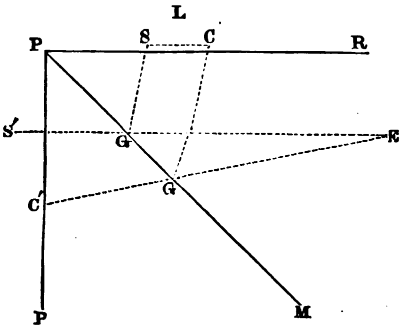
seen by reflection in the glass plate when the picture itself was seen through it, and that they should both thus be seen together, and at such relative distances from the eye as might best suit the effect desired. The first experiments were made with the view of introducing the appearance of the sun or moon bursting forth in the sky of the picture. This was done as follows, and succeeded to admiration:—In the annexed sketch P P represents the picture seen in its ordinary state



by light traversing it towards the eye at E; P M is a plate of transparent glass placed between the eye and the picture, while P R is another plate of glass or paper, on which a sky is painted, having a transparent portion to represent the sun or moon. So long as no light is allowed to fall on the plate P R, the picture is seen in its ordinary state; but so soon as the row of gas burners placed at L are turned on, the transparent portion at S, representing the sun, is seen by reflection in the glass plate at G, and appears to occupy a position in the sky of the picture at S′, and so with other portions of the sky, as C, &c. Figures were next tried, by being placed in a suitable position above the line of sight near E, and were made to appear or disappear in the picture according as light was allowed to fall on them from the gas jets, or was excluded. The apparatus, so adjusted, was exhibited to many persons, some of whom are members of this Society, in March, 1862. In proof of this I may read to the Society the following note:—

"I hereby certify that in the month of March, 1862, I saw at the residence of Dr. Taylor, of Glasgow, an apparatus for the production of apparitions of human figures, which came into view, or vanished suddenly or gradually in the position in which they appeared; and that the means of doing this consisted of a glass plate placed at an angle in front of the spectator, and so arranged as to be invisible to ordinary observation. The figures themselves were placed in an aperture in the roof of a box, to conceal them from view, and they appeared or vanished in the space behind the glass plate when the light which shone on them was turned on or lowered. I remarked, *This is the old magic revived,* and insisted that if a patent were taken, a fortune might be made of it.

"(Signed) W. ALEXANDER,
"Blockmaker, West Street, Glasgow."

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The following is from Mr. M'Nab, the well-known photographer:—

"I hereby certify that on various occasions in the month of March, 1862, and at subsequent dates of the same year, I saw at the residence of Dr. Taylor, of Glasgow, the appearance of figures and other movable objects introduced into the same field of view with photographic pictures as backgrounds. The figures, &c., were made gradually to appear in the space without visible motion of entrance, and in the same way they gradually or suddenly vanished in the place in which they appeared. The means of doing this I could not discover till it was pointed out to me. I then found it to be a glass plate of about seven square feet of surface, placed at an angle between the eye and the background. The figures, &c., were arranged in an opening in a board above the plate. They appeared as if in the space behind the plate when a light was allowed to fall on them, and vanished in an instant when it was shut off.

"(Signed) ALEXANDER M'NAB,
"98 West Nile Street, Glasgow.

"*18th November*, 1863."

The apparatus was shown and described at a meeting of the Glasgow Photographic Association on the evening of December 5, 1862, when it was stated that the arrangement was a mere model, and that as soon as plates of sufficient size could be got, the intention was to have them large enough to cover the end of the room, when such an exhibition as never yet had been possible, would be produced. The substance of the paper was published in London, in the *British Journal of Photography*, on December 15, 1862, with a description of the mode of using the glass plate, and its effects.

In January, 1863, the spectral illusion began to be shown in the Polytechnic Institution in London, and shortly took the name of "Professor Pepper's Ghost." It was said to be invented by Mr. Dircks, of Blackheath, while rumour stated that it had come from Glasgow.

Mr. William Glover, of the Theatre-Royal of Glasgow, has sent me the following note:—

"In the early part of 1863 I visited the Polytechnic Institution in London, for the purpose of seeing a really wonderful effect. I was told it was produced by the lime light. It was exhibited by Professor Pepper in much the same class of entertainment as at present. It was said at the Institution to be invented by a Mr. Dircks; but I was told even at that time that it was in reality the invention of a gentleman in Glasgow."

It ought to be noticed that the description of the glass plate placed in an inclined position, and the mode of using it for introducing

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spectral figures by causing a light to shine on *real* ones placed in a concealed position, was published by me in London, in December, 1862; and the exhibition of the glass plate placed in an inclined position, and spectral figures shown by admitting light to shine on real figures placed in a concealed position, was brought out in London in the month of January, 1863, or within about a month from the time of the publication of the description. [Since the reading of the present paper before the Society, one of the members of the Society has directed the attention of the author to a paper by Mr. Dircks, in the *London Mechanics' Magazine* for 1858, in which that gentleman describes a mode of producing spectral illusions by means of a glass plate. On looking over that paper, it will be seen that the mode proposed differs in two most essential *particulars* from the one described on the present occasion, which is the one now used for producing the "Ghost" at the Polytechnic Institution and elsewhere, the only difference being that the lime light is used instead of gas, which, in some respects, is the reverse of an improvement. These two *particulars* are,—*First,* That the plate is directed to be placed in a vertical position; and, *Second,* That the spectral figure only makes its appearance when the light in the space behind the plate is *lowered,* no mention whatever being made of causing it to appear or vanish without affecting the ordinary light in the room, by merely throwing light on the concealed figure, or excluding it. The spectators are also directed to look in by a narrow slit above the level of the glass plate.

[What I therefore assert is, that though Mr. Dircks had, as far back as 1858, proposed a method of introducing spectral figures by means of a glass plate, yet, that the mode proposed—viz., the vertical position of the plate and the appearance of the spectres only on the *lowering* of the light in the apartment—rendered its application, for the purposes of an illusion, worthless and impracticable; and as such it remained, as no attempt was made to put it in practice. On the contrary, by a course of experiments conducted without any knowledge of what Mr. Dircks had done, I showed, in 1862, the production of the spectres by means of the inclined glass plate, and the bringing out of the spectral figure by throwing a light on the concealed one, while the background illumination remains unaffected—an arrangement which constitutes the great peculiarity of the illusion, and is the sole cause of its success. I published an account of these methods in December, 1862; and the "Ghost" began to appear in London in about a month afterwards, shown by exactly the methods as published by me.]

The original apparatus in which the experiments were made was shown to the Society. It represented a miniature stage, with small

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figures, as in the marionette exhibitions. The spectral figures were shown as appearing and vanishing among the real figures, gradually or instantly, at the will of the exhibitor; and a spectral procession was introduced into a moonlight view of Holyrood Chapel, showing what could be done in giving life and interest to such subjects if exhibited on a large scale, and with adequate apparatus. At the same time a *dark* spectre was introduced along with a light one—the former appearing in front of and partly concealing the latter, while both were so transparent as to allow the background to be seen more or less distinctly through them. This curious appearance, now exhibited for the first time, was looked at with much interest.

The author of the paper then showed models and apparatus illustrating his views as to the causes of several natural phenomena which have long been subjects of interest, but have never till now, in his opinion, received their true explanation—such as the Spectre of the Brocken, the Flying Dutchman, the inverted ships in the air, the apparent transportation of Dover Castle across the hill on which it is situated; the spectral vessels on the Lake of Geneva, &c.

The mountain spectres he explained as resulting from a reflection of the mountain top, with its figures and the sky behind it, on a vertical film of air separating two strata of unequal density, in front of the spectators, and probably at no great distance from them. The spectators see their images in this film, and, having no criterion of distance, refer them to the surface of the distant cloud, and thus invest them with gigantic dimensions. An apparatus was shown, exactly reproducing this appearance.

The inverted and erect aerial ships were shown to result from a double reflection from the surface of the sea and a film of air nearly parallel with it at some distance above the level of the eye of the spectator. A model, consisting of two glass plates placed nearly parallel, with a model of a ship between them at one end, while the eye was placed between them at the other, *exactly* reproduced the appearances as described by Scoresby and others. These phenomena, which have hitherto been supposed to result from cast-shadows, or from refraction, are hence proved to be owing to reflection, in a manner at once simple and rational.

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II.—*On the Utilization of Sea-weed.* By Mr. Edward Alfred Wünsch.

Read December 16, 1863.

In submitting to you a few remarks on the utilization of sea-weed, I must refer in terms of grateful acknowledgment to Mr. Glassford's paper on "Kelp Manufacture," read before your Society so long ago as March, 1848—a paper which, for clear and concise statement, may serve as a model for all papers on industrial subjects. My endeavour will be to show that there is an immensely larger supply of this raw material than is generally supposed; and that, under an improved method, it may be made much more largely available than hitherto, not only for the production of kelp, but also for various other purposes, and chiefly for agricultural manures.

The production of kelp in the early part of the century—in the time of high protective duties, and in the absence of supplies of soda from other sources—was as much as 20,000 tons per annum. It afterwards fell off very considerably; and in 1848, at the time of the reading of Mr. Glassford's paper, was estimated at 6,000 tons, having received a considerable stimulus in consequence of the high prices of iodine in 1845 and 1846. Since then the annual supply of kelp has averaged about 8,000 tons, and during the last two years has risen to close upon 10,000 tons, as may be seen by the detailed statistical tables (Appendix A), showing the imports at the Broomielaw in each month of the year during the last twelve years. In the same tables the annual average price for iodine is stated for the same period; and after having, during a period of excitement in 1845 and 1846, risen to 40s. per lb., the price in March, 1848, stood at 10s. per lb., averaging 10s. 8d. for the last twelve years; and is at present lower than at almost any previous period—namely, 5d. per oz., or 6s. 8d. per lb. This low state of price is certainly in some degree compensated by the increased value of one of the other principal products of kelp—*i. e.*, muriate of potash—which, being an ingredient in the manufacture of gunpowder, has gradually risen from 7s. to 16s. per cwt., having at one time been as high as 22s.; and thus, however small the remuneration to the kelp-burner or landowner, the subsequent chemical manipulation in Glasgow has in the main been a flourishing branch of trade.

In France, with a less extent of sea-shore than our own, but with a more favourable climate, the production of kelp is estimated at 24,000 tons per annum. Assuming our present annual production of kelp to be 10,000 tons, this would require for its manufacture at least 200,000

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tons of fresh driftweed or tangle; and there is thus no difficulty in arriving at a correct estimate of this item: but the consumption of sea-weed in its wet or green state for agricultural purposes is more difficult to estimate. Owing to the large per centage of water (no less than 80 per cent.) contained in wet sea-weed, the cost of its cartage inland soon exhausts its value. Its use, therefore, is confined to the merest fringe of the sea-shore, and it can form but the merest fraction of the weight of farmyard and other manures applied to agricultural purposes over the country generally. Assuming it, however, to be equal in weight to the total weight of guano now used in this country, say 180,000, or in round numbers 200,000 tons, we have then the following estimate:—

200,000 tons used for manure in the green state; and other
200,000 tons used for the production of 10,000 tons of kelp; say a total of
400,000 tons of wet sea-weed consumed annually in the United Kingdom.

What proportion does this quantity bear to the available supply?

So small a proportion that it may emphatically be said that sea-weed, though classed as a raw material, has as yet scarcely been removed from the category of "waste products and undeveloped substances."

A paper on the "Economic Application of Sea-weed" was read by Mr. Stanford to the Society of Arts in February, 1862; and in the discussion which followed it was stated that "Great Britain alone, irrespective of Ireland and the Scottish Isles, possesses a sea-coast line of about 7,000 miles in length, with an average supply of sea-weed of 3,000 tons per mile." This would be nearly 1¾ tons per lineal yard, or a total supply of 21,000,000 tons—a quantity which at first sight appears so enormous that I endeavoured to check it by data supplied from other sources, and therefore applied for information to Mr. David Page, of Edinburgh, on whose judgment as a writer on physical geography, a geologist, and a keen observer of nature, I place great reliance; and he reduces the estimate of available sea-shore to 4,000 miles, and the average supply to 2,000 tons per mile, or a total supply of 8,000,000 tons.

Taking the first estimate, that of Mr. Wentworth L. Scott, the proportion would be—

One ton used for every 52 tons allowed to go to waste; and taking Mr. Page's estimate, the proportion would be—
One ton used for every 20 tons; or, striking an average between the two, the proportion would be—
One ton used for every 36 tons allowed to go to waste.

Whichever way we take it, I think I am justified in saying that sea-weed is as yet a "*waste product;*" and after glancing cursorily at its manner of occurrence and its inherent properties, I shall dwell more in detail

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upon a few suggestions as to its more extensive application to various purposes.

Although including many plants remarkable for their delicate beauty and minuteness, yet the bulk of the sea plants fringing our shores consists but of very few species, to which practically is confined the use as manure and the production of kelp. These are the three Fuci—

Fucus vesiculosus, F. nodosus, and F. serratus:

and the two Laminariæ—

L. digitata, and L. saccharina—

and I have mentioned these in the order in which they usually occur in zones or belts from the shore downwards. Mr. Stanford, in the elaborate analysis which he gives of these five, has added two others—the Zostera marina and the Rhodomela pinastroides—which occur in great abundance on the shores of the south of England, and contain all the usual ingredients of kelp. I am informed by Mr. Roger Hennedy that these two species are comparatively rare in Scotland; and that, on the other hand, two species not analyzed by Mr. Stanford—Halydris siliquosa and Hymenthalia lorea—occur plentifully on the shores of Scotland and Ireland, and constitute a fair proportion of the kelp worked up there. As the simplest manner of making these plants familiar to any of our members who may not have given their special attention to the subject, I have just brought up a rough bunch of each, such as may be picked out of the wrack, or collected at low water as near to our shores as Gourock; and to these I have added a bundle of sea-rods, or stems of the Laminaria digitata, not in the diminutive proportions in which these occur in the Frith of Clyde, but in the massive stalks from the south end of Kintyre, which constitute as it were the backbone of the best driftweed kelp produced there and on the Irish shores. Let us see, then, what can be said in favour of sea plants in their wet state.

Professor J. F. W. Johnston, in his *Elements of Agricultural Chemistry and Geology*, in speaking of the beneficial effects of the application of green manures, says:—

"Among green manures the use of fresh sea-ware deserves especial mention from the remarkable fertilizing properties it is known to possess. The farms on the Lothian coast are let for 20s. to 30s. more rent per acre when they have a right of way to the sea where the weed is thrown ashore. In this locality sixteen loads of sea-weed are reckoned equal to 20 tons of farmyard manure."

Dr. Thomas Anderson, in his *Elements of Agricultural Chemistry*, says:—

"The ease with which all sea-weeds pass into a state of putrefaction adapts

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them in a peculiar manner to the requirements of a cold and damp climate. . . . . . They form, therefore, a rapid manure, and their effects are said to be confined to the crops to which they are applied; but this is probably due to the fact that they are chiefly used in inferior sandy soils, in which any manure is rapidly exhausted. In good soils there is *no reason* why their effects should not be as lasting as that of farmyard manure, which in many particulars they considerably resemble."

Finally, Professor Johnston, in his *Lectures on Agricultural Chemistry*, sums up as follows:—

"It is of importance to bear in mind that the saline and other inorganic matters which are contained in the sea-weed we lay upon our fields *form a positive addition to the land.* If we plough-in a green crop where it grew, we restore to the soil the same saline matters only which the plants have already taken from it during their growth, while the addition of sea-weed imparts an entirely new supply. *It brings back from the sea a portion of that which the rivers are constantly carrying into it,* and is thus valuable in restoring in some measure what rains and crop are constantly removing from the land."

But to show the difficulty of bringing into profitable use so bulky a substance, I may quote a passage from Mr. P. L. Simmonds' *Waste Products and Undeveloped Substances*:—

"A deposit of sea-weed," he says, "of a million tons or more, nearly equal to the best guano, has been going on for centuries in the Isle of Foulney, at the outlet of the tidal river ten miles from Ulverston. Although it is little used generally, it has been successfully employed on a farm there for the last ten years."

The announcement of so interesting a deposit could not fail to attract my attention. I accordingly visited the locality, but found that although the sea-weed had been carried by the tides into a sheltered estuary, where it had accumulated and gradually subsided, yet it was, at the same time and from the same cause, accompanied by such sediments of sand and mud as to make it certainly undeserving of the qualification of "*nearly equal to the best guano,*" and practically useless at any greater distance than the immediately adjoining shore.

And this example represents in substance the difficulty—insuperable, it must be feared—of extending the use of green sea-weed as a manure to any distance inland.

If, however, the same substance could be economically deprived of its 80 per cent. of water—that is to say, reduced four-fifths in weight—we could then give to the farmer, in the same bulk, five times the quantity of valuable salts contained in the wet sea-weed, and thus enable him to carry it five times the distance, or, indeed, make the material accessible to railway carriage: and as my proposal for a more

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extended use of sea-weed turns very much upon this point, of obtaining it economically in its dried state, and as the production of kelp also depends entirely upon the degree of success attending the drying of wet sea-weed, I would invite your attention to the analytical tables (see Appendix B and C), both for dried sea-weed and for charred or burned sea-weed, and to the remarks referring thereto. The tables of valuable constituents quoted from different authorities are quite sufficient to inform the mind through the eye, and I need not repeat them or dwell upon them in detail.

Starting, then, with the fact that a ton of dried sea-weed contains five times the valuable ingredients of a ton of wet sea-weed, it may in its dried state become of great value to the farmer, more particularly in inland districts. An estimate by Dr. Penny of its value as a manure, founded upon the money value of its chemical ingredients, is as follows:—

VALUATION OF 100 TONS OF DRIED SEA-WEED AS MANURE.

Organic Matter, 67·47		
Less Ammonia, 1·8		
——— 65·67, ...	@ 10s.,	£32·84
Potash, 3·21 = 5·09 Chloride of Potassium = 6·36 Commercial Muriate, at 80 per cent., ...	@ £16,	101·76
Alkaline Salts,—		
9·88, less Chloride of Potassium, 4·79, ...	@ £20,	4·79
Phosphates, 2·03, ...	@ £7,	14·21
Ammonia, 1·80, ...	@ £60,	08·
Insoluble Salts of Lime and Magnesia, 3·39, ...		—
		£261·60

Equal to £2 12s. 0d. per Ton.

a value which in practice it could probably never attain. But supposing it to be only something approaching the value of straw, it may serve as a substitute for that useful material for many purposes not hitherto thought of, and thus help to allay the jealousies of landlords against farmers carting the straw off the land: for all objections would be silenced if, against every ton of straw, containing 70 to 360 lbs. of mineral ash, which has been carried off, a ton of dried sea-weed were laid on, containing no less than 560 lbs. per ton of valuable mineral ingredients.

So far for dried sea-weed, which, as by the analyses given, contains still a very large proportion of organic matter, no doubt valuable to the farmer, but seriously impeding its carriage to any great distance. But, whenever requisite, all this organic matter can be got rid of by burning, and we have then the charred ash, with a greatly increased per centage of mineral salts, or, if fused, the kelp as used by our chemical manufacturers.

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On this subject Professor Johnston, already quoted, says as follows:—

"Kelp is the ash left by the burning of sea-weed. It contains potash, soda, lime, silica, sulphur, chlorine, iodine, and several other of the inorganic constituents of plants which are required by them for food. It is nearly the same also, with the exception of the organic matter which is burned away, with the sea-weed which produces such remarkably beneficial effects upon the soil. . . . Kelp may be applied to the land in nearly the same circumstances as wood-ash; but for this purpose it would probably be better to burn the sea-weed at a lower temperature than is usually employed. By this means, being prevented from melting, it would be obtained at once in the state of a fine powder, and would be richer in potash and soda. It might lead to important results of a practical nature were a series of precise experiments made with this finely divided kelp as a manure, especially in inland situations; for if the quantity of chloride of potassium it contains be an average nearly as great as is stated in the analysis of Gay-Lussac, kelp will really be the cheapest form in which we can at present apply potash to the land."

For the analysis of Gay-Lussac see Appendix C. He further says:—

"There are two principles on which the value of different vegetable substances as manures may be estimated—

"*First*, The relative quantity and kind of inorganic matter they respectively contain; and

"*Second*, The relative proportion of nitrogen present in each.

"Valued according to the quantity of inorganic matter they contain, the worth of several kinds of straw, hay, &c., would be represented by the following numbers:—

"A *ton* weight of each substance, when made into manure, provided nothing is washed out by the rains, will return to the soil the following quantities of inorganic matters in pounds:—

"Wheat straw, ...	70 to 360
Oat straw, ...	100 „ 180
Hay, ...	100 „ 200
Barley straw, ...	100 „ 120
Pea straw, ...	100 „ 110
Bean straw, ...	100 „ 130
Dried Sea-weed, ...	560"

After adverting to relative quantities of nitrogen, the author continues:—

"The reader will form an opinion alike consistent with theory and practice if he concludes,

"1. That the *immediate* effect of vegetable manures in hastening the growth of plants is dependent, in a great degree, upon the quantity of nitrogen they contain and give off during their decay in the soil; *but*,

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"2. That their *permanent* effect and value is to be estimated chiefly by the quantity and quality of the *inorganic* matter they contain, of the ash they leave when burned."

I have placed upon the table a few rough specimens both of the dried sea-weed and the charred and powdered sea-weed; and with respect to the operation of drying, as hitherto conducted, preparatory to the burning into kelp, will proceed to sum up the disadvantages enumerated by previous writers upon the subject.

Mr. Glassford says:—

"It is of the utmost importance for all the operations of the kelpers that they should have clear and dry weather, but more especially so for the drying and burning operations. When the weeds get wet from rains, or even have to remain moist from the want of sun heat, fermentation ensues, the weeds become quite soft and pulpy, run together into masses, and finally disappear. Even when dry weather should interrupt this waste, the decomposing wrack is with difficulty saved, and the kelp prepared from it is inferior."

Mr. Stanford also states:—

"Even in the summer, during a wet season, large quantities of driftweed collected by the kelpers are rotted by the rain, and rendered useless for burning; and this, says Mr. Paterson, was the fate of many thousands of tons during the last kelp season."

The season alluded to by Mr. Paterson was probably the same as that described by Alexander Smith, the poet, who spent his summer holidays in the Isle of Skye in 1861, and states that, out of thirty-one days in August, there were twenty-seven days of incessant rain, and four days of partial rain!

Having thus sketched the present state of matters with regard to the subject in hand, I shall conclude with a brief outline of my proposal for an improved treatment of the material. The enormous quantity of the raw material, as already referred to, and the difficulty of securing anything like an adequate proportion in the dry state by natural means, suggest the alternative of employing artificial means; but the excessive quantity of water contained in sea-weed, and the cost of fuel consumed in expelling the moisture by the ordinary means of heating, would at once raise the cost of the dried material beyond all profitable use. We can therefore expect to arrive at a practical result only if large quantities can be thus dried at a comparatively small expenditure of fuel, particularly in localities where the price of coal, owing to the cost of carriage, will be considerably enhanced. This desideratum is supplied by the process of "*burning wet fuel*" practised successfully in America, and of which the following, taken from a scientific periodical, is a condensed account:—

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"Mr. Moses Thompson, an American, wished to construct a furnace to burn the *begasse*—that is, the waste cane of a sugar-plantation; and persevering with this object in view, at last succeeded. He was led to conclude that the great quantities of steam, smoke, and other products which are thrown off when wet fuel first begins to burn, would, as he describes it, 'consume each other,' if sent into a chamber heated to a sufficiently high temperature, and from which the external air should be excluded. The furnace is built with three or four compartments, all of brick. One of these compartments, used as the 'mixing-chamber,' must be built of the most refractory fire-brick. The fire is first lighted with dry fuel, and kept up till the brickwork is heated: the doors are then shut, and the wet fuel, crushed cane, tan, or dye-stuff, is fed in from an opening at the top, and after awhile the steam, smoke, and gases evolved pass onwards into the mixing-chamber, and are there entirely consumed. *The heat developed is so intense that the chamber appears of a white heat, and the damper must be made of fire-clay, as iron is speedily melted.* Mr. Thompson says that the results obtained by his process with wet fuel far exceed any that can be obtained with dry fuel; and to exhibit what can be accomplished, it is shown that peat containing so much as 75 per cent. of water can be advantageously burned."

Through the kindness of Professor Rogers, I was enabled to obtain the specification and particulars of the process referred to; and I have the details of it in my note-book, at the service of any of our members who may take an interest in the subject: but, to save your time, I shall not further enter upon it here, as it is in substance the same as the extract already given. I shall only quote the closing paragraph of Professor Silliman's account, which is as follows:—

"Even fuel otherwise entirely valueless, such as *wet peat*, containing over 75 per cent. of water, was rendered efficient by this process, three cords of 128 cubic feet of wet peat, and one cord of dry wood, doing the duty of four cords of dry wood in driving a steam boiler."

I found this process equally applicable to sea-weed; and in my own experiments, made on a comparatively small scale, I found that about an equal quantity of coal and sea-weed were required to produce the intense combustion as described. To explain the chemical action which takes place, it may be desirable to quote the following from Professor Silliman:—

"The vapour of water is decomposed, furnishing its oxygen to the highly heated carbon to form carbonic acid, while the oxide of carbon is in like manner exalted to the same condition, and any excess of carbon forms, with free hydrogen, marsh gas, or light carbureted hydrogen. The vapour of water is thus made to give up, not only its constituent elements to form new compounds with oxygen, producing in the change great heat, but a great part of the heat absorbed by water in becoming steam is also liberated in this change of its physical and chemical constitution. . . . Such is the intensity of

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heat in that portion of the furnace where these re-actions take place, that only the most solid structures of refractory fire-bricks will endure it; and the colour seen throughout that portion of the furnace is of the purest white. . . . Theoretically, no more heat can be generated in this mode of combustion than is consumed in the transformation of water into steam, and the conversion of fixed into volatile products. But it is by no means a matter of indifference whether the oxygen necessary for complete combustion is drawn from the atmosphere, or is derived from the decomposition of water by carbon and its oxide. In the former case, not only is there a great loss of heat, carried away by the inefficient nitrogen of the air, but the diluted oxygen can never produce so intense a heat with the carbon as is the result of the re-action of the nascent oxygen with that element."

The economy of fuel thus effected is probably capable of further increase when the operation is carried on continuously and on a large scale; and is at all events sufficient, in combination with a well-arranged drying apparatus, to admit of sea-weed being dried artificially, at no greater expenditure of fuel than one ton of coal for every ton of kelp produced. In the drying apparatus, I propose, in combination with fans to produce currents of air, to use a simple contrivance of endless chains or webs, on which the sea-weed is carried forward and tossed from one stage on to another,—imitating, in fact, as near as possible, the natural operation of drying sea-weed, hay, or any other wet substance, by turning it over in the hot sun, and allowing the breeze to play freely upon it. By this means, with a compartment constructed on an appropriate scale, a ton of wet sea-weed may be operated upon and turned out perfectly dry in thirty minutes; and supposing the operation continues,

48 tons could be turned out during 24 working hours, producing about
12 tons of dried sea-weed; or if the same be at once reduced into kelp by burning, giving about
3 tons of kelp.

These are not the only mechanical appliances which in my opinion it would be necessary to introduce, in order to work up profitably so bulky and unpliable a material as wet sea-weed. Great expense and labour are incurred in the mere preliminary process of carrying the weed in boats, or in carts or hand-barrows, to suitable drying and burning places; and in case of any fixed erection on shore, there might soon be a scarcity of supply in the immediate neighbourhood, necessitating the carrying of the wet stuff from a distance at a considerable expense.

In the treatment which I propose it is therefore contemplated to have erections on the shore, movable, if required, from one point of the coast to another—with the alternative, on such places on the coast as may admit of it, of having the machinery as described transferred into

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a floating apparatus, thereby saving the great expense of conveying the sea-weed ashore, and opening up the profitable use of many shores which may not be accessible to the operations of the kelp-burner, as at present carried on. I have grounds for believing that, by the use of very simple appliances, in combination with the above proposals, a very much larger supply of sea-weed could be obtained from comparatively small areas; but I conclude by summing up the advantages aimed at in my proposal as follows:—

1. The profitable use of the large quantities of driftweed thrown up during winter, and now almost entirely lost.

2. The production of dried sea-weed in large quantities, and at a cheap rate, for manures.

3. The production of charred or powdered sea-weed for the agriculturist as well as for the kelp manufacturer.

4. The production of kelp in the same shape as hitherto, but richer in valuable ingredients, owing to the saving of all loss from rain or fermentation, and free from the admixture of sand and gravel.

And last, but not least, extended employment for the population on our western shores, and that during the greater portion of the season in which they are at present least employed.

Sea-weed is no doubt one of the most valuable, as it is one of the most stubborn, of our raw materials; but no one will maintain that, because hitherto it has been treated only in the rudest and most primitive manner, the difficulties of bringing so important a product into more extended and profitable use could not be successfully encountered; and that we could not add another to the long list of materials which have already been rescued from neglect or oblivion, and now help emphatically to fulfil the great dictum and desire of the philanthropist, "to make two blades of grass to grow where only one grew before."

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APPENDIX A.

ANNUAL AVERAGE QUANTITY OF KELP BROUGHT INTO GLASGOW FOR TWELVE YEARS, 1850-51 TO 1861-62, FROM TABLES COMPILED BY MR. CUTHBERTSON.

1851, . . .	11,421 tons,	Price	$8\frac{3}{4}$d.	to	8d.	per oz.
1852, . . .	7,320 ,,	,,	7d.	to	$6\frac{1}{2}$d.	,,
1853, . . .	5,418 ,,	,,	$13\frac{1}{4}$d.	to	$11\frac{1}{4}$d.	,,
1854, . . .	6,491 ,,	,,	12d.	to	$11\frac{1}{2}$d.	,,
1855, . . .	4,879 ,,	,,	$9\frac{5}{8}$d.	to	9d.	,,
1856, . . .	5,826 ,,	,,	$10\frac{5}{8}$d.	to	10d.	,,
1857, . . .	6,349 ,,	,,	$9\frac{1}{2}$d.	to	$9\frac{1}{8}$d.	,,
1858, . . .	8,641 ,,	,,	$8\frac{1}{4}$d.	to	$7\frac{1}{2}$d.	,,
1859, . . .	8,123 ,,	,,	$7\frac{3}{8}$d.	to	$7\frac{1}{8}$d.	,,
1860, . . .	7,754 ,,	,,	$6\frac{5}{8}$d.	to	$6\frac{1}{8}$d.	,,
1861, . . .	9,722 ,,	,,	$5\frac{1}{2}$d.	to	5d.	,,
1862, . . .	9,414 ,,	,,	$5\frac{1}{2}$d.	to	5d.	,,
Average,	7,613 tons,	Average,	$8\frac{3}{4}$d.	to	8d.	per oz.

APPENDIX B.

COMPOSITION OF VEGETABLE MANURES—SEA-WEED—FROM DR. T. ANDERSON'S "ELEMENTS OF AGRICULTURAL CHEMISTRY."

	Fucus Nodosus.	Fucus Vesiculosus.	Laminaria Digitata. Collected in Autumn.		Laminaria Digitata. Stem and Frond collected in Spring.
Water, ...	74·31	70·57	88·69		77·31
Albuminous Compounds, .	1·76	2·01	0·93		3·32
Fibre, &c., ...	19·04	22·05	4·92		10·39
Ash, ...	4·89	5·37	5·46		8·98
	100	100	100		100
Nitrogen, ...	0·28	0·32	0·15		0·53
The Ash consisted of . .			Stem.	Frond.	
Peroxide of Iron, . .	0·25	0·35	0·20	0·50	0·45
Lime, ...	9·60	8·92	7·21	7·29	4·62
Magnesia, ...	6·65	5·83	2·73	5·91	10·94
Potash, ...	20·03	20·75	5·55	11·91	12·16
Chloride of Potassium, .	—	—	58·42	26·09	25·83
Iodide of Potassium, . .	0·44	0·23	1·51	2·09	1·22
Soda, ...	4·58	6·09	—	—	—
Sulphuret of Sodium, . .	3·66	—	—	—	—
Chloride of Sodium, . .	24·33	24·81	15·29	30·77	19·34
Phosphoric Acid, . .	1·71	2·14	2·42	2·56	1·75
Sulphuric Acid, . . .	21·97	28·01	2·23	8·80	7·26
Carbonic Acid, . . .	6·39	2·20	4·11	2·49	15·23
Silicic Acid, . . .	0·38	0·67	0·33	0·99	1·20
	100	100	100	100	100

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APPENDIX C.

Analysis by Professor F. Penny.

	Of Dried Sea-weed.		Of Kelp.	
	Per Cent.	Lbs. per Ton.	Per Cent.	Lbs. per Ton.
Water,	16·00	358·40	—	—
Organic Matter,	67·47	1,511·33	—	—
Soluble Salts,	9·88	221·31	60·00	1,344·0
Insoluble Salts,	5·42	121·41	32·52	728·5
Sand,	1·23	27·55	7·48	167·5
	100	2,240	100	2,240
Potash,	3·21	71·90	19·45	435·68
Iodine,	0·09	2·01	·55	12·32
Ammonia,	1·80	40·32	—	—
Phosphates,	2·03	45·47	12·35	276·64
By Dr. W. Wallace,—				
Potash,			20·00	448·00
Iodine,			13·00	29·12
By Gay Lussac,— Normandy Kelp—				
Chloride of Sodium,			56·00	1,254·00
Chloride of Potassium,			25·00	560·00

Memoir of the Glasgow Cathedral Windows.

By Mr. C. Heath Wilson.

Read February 10, 1864.

It has been suggested to me that a memoir of the history and progress of the Glasgow Cathedral Windows might be of sufficient interest to merit the attention of this learned Society; in compliance with that suggestion I present myself before you this evening. A paragraph in the *Glasgow Herald* of Friday the 22d February 1856, informs the public that Sir Andrew Orr then Lord Provost, made an interesting statement on the previous day to the Town Council, that "by the generous and liberal feeling of some of our citizens," and with "the co-operation of Government, it might be anticipated that the whole of the windows in the Cathedral would be filled with painted glass." The list of subscriptions published in the ensuing

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September contained the names of fifty-nine subscribers representing forty-eight windows. The subscribers attended their first general meeting upon Thursday the 4th day of September 1856, when the following resolutions were adopted and published:—*First,* That it is desirable to complete the restoration of the Cathedral of Glasgow by filling the whole of the windows with painted glass. *Second,* That it is desirable that the subscribers to this interesting and important undertaking should unite in promoting the adoption of a harmonious plan of decoration, suitable to the character of the building, and worthy of the purity and dignity of its architecture. The *third* and last resolution appointed a Committee, with Office-bearers, "to procure information as to the best means of carrying the foregoing resolutions into effect."

We cannot fail to advert with sadness to the names of active and valuable members of that Committee who have passed away. The Duke of Hamilton—who contributed so munificently to the undertaking, who took so deep an interest in the work, who was ever ready when consulted, to give that advice which his loving study of art so well fitted him to afford, and who promoted in a pre-eminent degree the success of the undertaking. The late Earl of Eglinton, whose memory lives in the affections of his countrymen, was also an energetic and assiduous member, whose name must likewise ever remain prominently connected with the painted windows. Amongst those whom we have lost was the amiable and accomplished Dr. Strang, Treasurer to the Committee, whose business experience, and calm, judicious advice, were ever at the service of the members. In his love for Glasgow, and all that could improve or adorn it, he took a profound interest in the Cathedral, and his name must be permanently held in honour in connection with the history of its restoration.

The enterprise is now, in the eighth year of its progress, approaching completion: the functions of the Committee do not cease, however, with the erection of the last of the principal windows of the nave and choir, as a plan has been recommended to Government and has been approved of, for filling the clerestory windows with painted glass in harmony with those below, and by artists of the same school. Some progress has already been made, as six of these windows have been commissioned, and there can be no doubt of the importance of this plan to the complete adornment of the Cathedral. It is proposed that these windows shall contain figures, and not mere diaper work or ornament as has been recommended by some who take an interest in the subject, experience having proved that subscribers will not come forward unless the window subjects are made sufficiently interesting.

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I have read to you the resolutions of the first meeting of subscribers —the second of these resolutions may be considered the text of any remarks upon the subsequent proceedings of the Committee. It is therefore necessary to bring it under your special notice. It is to the following effect:—

"That it is desirable that the subscribers to this interesting and important undertaking should unite in promoting the adoption of a harmonious plan of decoration, suitable to the character of the building, and worthy of the purity and dignity of its architecture."

Various interpretations have been put upon these words, but it appears to me that there can be no doubt of their true meaning. It was ascertained, by a tour of visits to famous English Cathedrals and other churches containing numerous specimens of modern glass painting, that however harmonious the architectural unity of those edifices or of portions of them, donors of windows had been permitted to carry out their special ideas of design in glass painting or to give free course to their caprice, with small thought of the true spirit of the architecture or of the importance of making the painted windows accord with each other. This is particularly observable in the superb nave of Lincoln Cathedral and throughout that of Ely, as well as in other noble edifices built in the great ages of architecture, in all of which the painted windows so profusely introduced of late years have been brought together without concert or plan. In these chance medley collections there is as little connection between the windows as between the pictures in an exhibition or picture gallery.

No person possessed of sentiment, or of a knowledge of the laws of architecture, visits Westminister Abbey without experiencing pain and regret—hardly relieved by the evidence of homage to genius and heroism — from the heterogeneous collection of monuments which encumber, disfigure, and hide so much of that noble pile. There is less excuse for the random collections of modern painted windows, erected in buildings of equal beauty and importance, which harmonize with them neither in the *letter* nor in the *spirit*. A Cathedral is not a museum.

Works of art, including painted glass, could only harmonize in the *letter* with the architecture when executed contemporaneously with it, they may in the *spirit* at whatever period they are executed; for they may be monumental in character, great in design, solemn in colour, and consistent in style with each other, although not in the letter of the style of the edifice. It appears to me that this was the feeling which animated the great masters of the great epochs of art; they abhorred pretences, shams, and forgeries of old art—it was left for the present

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age to perpetrate these—the result has been the reduction of this important branch of art to little more than a manufacture.

I have alluded to instances of what must be considered chance medley church decoration,—I now wish to bring under your notice examples of the opposite system. At an early period of the inquiries made into the state and progress of glass painting, visits were paid to cathedrals and churches in the centre and on the east side of England—to London, Oxford, and Cambridge—and nearly every window of importance was examined. Subsequently these visits of inspection were extended to Chester, and cathedrals on that side of England, and, at the same time, to Rouen, Paris, Chartres, Orleans, Bourges, and Lyons. The finest examples of the nearest approach to identity of style between the painted glass and the architecture are in the Sainte Chapelle, at Paris, and the magnificent Cathedral of Chartres. The first of these interesting and splendid monuments of ancient genius contains a series of medallion windows of the thirteenth century contemporaneous with its architecture, and lately restored with most praiseworthy skill. The Cathedral of Chartres contains one hundred and twenty-five aisle, transept, and choir windows, three immense rose windows, thirty-five other rose windows of medium size, and twelve smaller rose windows. With the exception of eleven, the whole of this magnificent series of one hundred and seventy-five windows is filled with thirteenth century painted glass. The architecture of the church presents, as usual, a progression of ideas from the twelfth century, but its most important features are early pointed. We have, in this great monument, the most imposing existing example of a contemporaneous style of architecture and painted glass, but magnificent as the glass is in colour and general effect, the architecture is already immeasurably in advance of painting as it was then practised, with its inability to represent the human form with even an approach to correctness, its ghastly expression, and its want of life. Painting was then at its lowest ebb, architecture having almost reached its perfection.

A considerable advance in the painter's art took place in the next century, which was certainly to be attributed to the beneficial influence of the study of nature, especially observable in the beautiful ornamentation of this period; and when artists were required to execute painted glass for churches of the preceding age, it never occurred to them to design in the barbarous style of art from which they were emancipating themselves—consequently we find fourteenth century glass in buildings of earlier date—demonstrating that the men who did this were true artists in the truest sense of the term. Painting did not stand still: the efforts of the painters of those

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days were onwards—upwards. The style of the fifteenth century, which we term the Perpendicular, was next developed; a power of drawing and grouping was attained in the art of the north of Europe which, if not so great as in the contemporaneous art of Italy was still in advance of preceding times. In the magnificent twelfth century apsides of the Cathedral of Tournay we find the finest existing fifteenth century glass: the admirable artist of these admirable works did not denude himself, so to speak, of all his knowledge and skill, and paint windows in the rude manner of the twelfth century that he might assimilate them to the architecture. I repeat what I have said before—like other true artists he despised shams. In the sixteenth century—the cinque-cento of the Italians—glass painting reached its highest development, and we find in the Gothic Chapel of the Sacrament, in the Cathedral of Brussels, in the Gothic Churches of St. Patrice and St. Vincent at Rouen, and in other monuments which might be referred to, that the painted glass is cinque-cento—not Gothic, for it was executed in the sixteenth century. These examples may suffice to illustrate the practice of the great masters of the art of glass painting.

From the models which I have selected we have the principle established of unity of style between the architecture and the glass painting when both were executed at the same time or during the prevalence of a style. When, however, a series of windows were executed at a later date than the stone work, we have unity of style in the windows themselves but not with the stone work—thus there is a departure from the letter of the style—but, as I have already remarked, there is none from the spirit so long as true views of monumental art survived. We further learn, that it was the universal practice of the old masters of art to work in conformity with prevalent ideas, and in harmony with the tendencies and character of the age in which they lived.

The second idea set forth in the resolution "of a decoration worthy of the dignity and purity of the architecture," did not therefore imply any imitation of the style of painting prevalent when the Cathedral was built. Painting was then in its infancy, architecture had almost reached its mediæval perfection; to unite bad art with good art by an imitation of that which was defective, merely on account of identity of date, would, I think, have been intolerable, and is so wherever it is now done—it may be to act in accordance with the letter but certainly not with the spirit of the architecture. I allude particularly to representations of the human figure, and I regret that the commonplace word "decoration" was used in the resolution, seeing how low is its modern significance,—I speak of depicting scriptural events and

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characters—of a desire in doing so, to convey instruction to the people through their eyes, to elevate their tastes by exalted representations of the subjects chosen for the windows. Besides the notorious defectiveness of mediæval painting in respect of truth of form, beauty, life, and movement, we have also to remember that mediæval representations were in reality hieroglyphics of mediæval ideas of doctrine and faith; they are invariably legendary even when the subjects are scriptural. When I refer to our specification I shall return to this important objection to the imitation of old forms of glass painting in a Scottish Church. The question naturally arose in considering this portion of the subject,—is Protestantism incapable of creating modes of representation in harmony with its own earnest views of truth, and must we, as they so frequently do in England, pilfer all our ideas from mediæval Romanism? The question was debated beyond the walls of the Committee room, and articles bearing on it appeared in various papers at the time, and there seemed to be some danger of narrowing it within the limits of sectarian views. This was a danger on the other side; the Committee manfully steered its bark between these opposite dangers, and the subjects selected were scriptural only. There was no disposition to reject precedent or the experience of past ages where these threw light upon the path of the Committee; on the contrary, wherever these afforded aid they were taken advantage of with a just sense of their importance, excluding only what was not applicable to the present times and to present modes of thought.

At a very early period, series of biblical types and antitypes were adopted in the works of art with which churches were adorned, and in most cases we find a general correspondence in the order of the subjects. A work entitled the *Mirror of Human Salvation* was much followed by artists in the cycles of scriptural types which they painted or sculptured; the general idea had reference to the scheme of revealed religion as a whole, and the representations were usually so arranged that the types and antitypes were placed near each other. In the great south window of our Cathedral may be observed an illustration of this ancient arrangement of subjects; the two leading principles of the ancient method have been followed in the selection made for the Cathedral windows—namely, a grand general idea set forth in the whole series, and a succession of subjects bearing upon this general idea. Those for the nave of the Cathedral were selected from the Old Testament, those for the present church from the Gospels, and it was originally intended that the windows in the east end, commonly called "The Lady Chapel," should contain illustrations of the promulgation of the Gospel throughout the world, but owing

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to the small size of the windows, and for other reasons, it was thought better to substitute figures of the Apostles, the first preachers of that Gospel; lastly, in the great east window are placed the Evangelists. The first plan contemplated by the Committee, and published in the Appendix of their Report, included one group of figures only in the centre of each of the triplets, two groups in the couplets, and the design now executed in the great windows, and that the rest of the glass was to be filled with ornament only. The Chairman of the Committee, however, suggested that this idea should be enlarged, and that there should be a figure subject in each division of all the triplets; this involved one hundred and twenty-four subjects as against seventy-five, and, consequently, a considerable increase of cost. A new list of appropriate illustrations was prepared, nor was this so easy a task as may at first sight appear. Besides their selection, so as to bring in as many as possible of the most important persons and events of Scripture history, and their chronological arrangement, it was necessary to choose those which could be effectively represented in spaces not exceeding, in the aisle windows, twenty-four inches in width, some being still narrower, and which could also be executed within the technical conditions of glass painting. This being done, the new scheme was laid before the subscribers and the new outlay explained; to their liberality and intelligence it is owing that the Committee have been able to carry out the series of Bible illustrations on the existing magnificent scale.

The Committee decided, after much consideration and a careful examination by some of its members of specimens of modern glass painting in various parts of the United Kingdom, to recommend that the Glasgow painted windows should be executed at Munich. This recommendation as well as the general plan of the Committee received the sanction of the subscribers at a meeting held on the 5th June 1857, and the Committee was re-appointed to carry out the work. It may be needful that I should advert here to the opposition which was made to the plans of the Committee when they were published. The various aspects of the contest which ensued form portions of the history of the Cathedral windows not destitute of interest or importance, but this is neither the time nor the place for entering upon this history; the conscientious opinions of the opponents of the scheme were chronicled in all our journals and in various papers published in different parts of the kingdom. It was a manly stand-up fight for the time being, and I would venture to express a hope that whatever "punishment" may have been received on either side is only remembered now in the spirit of true British pluck and fairness. The ideas which prevailed in the

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councils of the Committee in 1857, and which are detailed in the voluminous correspondence and official documents which have been carefully preserved, form an important portion of the history of the windows. It was wished that in the nave, with its Old Testament subjects and its history of a stern dispensation, the combination of colours should be such as to produce a grave and solemn effect, for as the nave is now used only as a vestibule to the church, the prevalence of deep tones of colour could not be attended by inconvenience to the congregation, and would also harmonize with, and give effect to the simplicity and largeness of style characteristic of the architecture of this part of the Cathedral. In the church, with its New Testament subjects, its lessons of charity, love, and mercy, the design and colour might it was thought be richer and more brilliant; it was felt to be desirable that as much white glass should be employed as would be consistent with general harmony of effect. In the so-called "Lady Chapel" a graver scale of colour and a simpler style of ornament were thought desirable as a means of giving greater brilliancy to the other windows of the church, especially the east window placed over them; and because the lancets of the east end are opposite to the eyes of the greater part of the congregation, for their comfort it was wished that these should be quiet and cool in colour. With regard to the effect to be produced upon the architecture of the church there could be no hesitation in filling all the windows, as it is well known that Gothic churches were designed with a view to the introduction of painted glass,—hence the deep undercuttings in mouldings, ornaments, and statues, where these exist; painted glass also increases the apparent size of an edifice and substitutes a pleasing repose for the garishness which always results from numerous windows and cross lights glazed with white glass only. In the beautiful floriated capitals of the piers of the choir, a lesson is given in that similarity and balance of proportion with variety of detail characteristic of Gothic architecture, so that, whilst in the same spirit it was thought that there ought to be a general similarity in the painted windows, yet the variety of detail might be infinite. Again, it was felt that there ought to be the same variety in the general colour of the groups of windows, that each window ought to be perfect in itself, and at the same time in harmony with, although differing in the general arrangement of colour from those near it, whilst it was also desired that, for the preservation of architectural unity, the same harmonies of colour should re-appear at fixed intervals. A severer style of art was contemplated than has been realized. When, however, it was found that the rigid principles laid down could not in every instance be adhered to, it was felt to be useless to attempt coercion,

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which might have led to the worst effects upon the artists themselves. They were men of high professional eminence, some of them of European reputation, all possessed of great experience, they entered into the views of the Committee and donors with the utmost courtesy and cordiality; but, whilst they desired to carry out views which differed in important particulars from those upon which they had acted in all previous works, it was obviously requisite that there should be conciliation on both sides. A correspondence, which has now lasted for seven years, and which has embraced many delicate, not to say difficult points of discussion, has been maintained throughout in the best possible spirit, and leaves absolutely nothing to be regretted on either side.

The method of execution was a subject of serious importance. All modern glass, as compared with old, is too thin and transparent, and is deficient in softness of colour. The Munich artists before 1857 endeavoured to overcome this transparency by a free use of enamel, so as to dim to a considerable extent the over-transparency of the glass and to moderate its tones. The plan adopted by our own glass painters differed in some particulars, but by all the great defect of the modern material was felt and obviated as much as possible in the execution of the painted glass. It was evidently desirable that the windows should be pure Mosaics, every required colour being leaded in its place as in the old manner, that one shade colour only should be used, and that, so far as the technical execution of the painted glass was concerned, it should be in accordance with the practice of the best periods of glass painting, but in no pedantic spirit: the glass was not to be broken up merely to be leaded together again to imitate old glass made when imperfect mechanical skill disabled the manufacturers from producing large sheets. As our progress in art in the nineteenth century was not to be ignored in the design, neither was our progress in manufacture to be concealed.

At the risk of repetition I will now read some extracts from the specifications sent to the artists. Similar expressions to those which I have already used may occur, but I am anxious to state clearly and explicitly the principles upon which this great work has been conducted. The specifications were accompanied by plans, elevations, and sections of every part of the Cathedral, by numerous coloured tracings from choice specimens of old painted glass existing in England, and by templets of full-sized patterns of the windows, cut with perfect accuracy. The first extract which I shall bring under your notice is the following: it was addressed to artists of the Roman Catholic faith, and was therefore explicit in its expressions:—

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"It must not be forgotten that Glasgow Cathedral is a temple dedicated to the religious services of the Established Church of Scotland. The Established Church of Scotland is a Protestant and Presbyterian Church. According to the principles and practice of this church, no representations in painting or sculpture are anywhere admitted for religious purposes. The services are very simple: there is no pomp, no symbolism; and there is the greatest repugnance to the symbolism of Rome. You must therefore avoid in every case using any symbol adopted in Roman Catholic Churches."

A list of these symbols was then given:—

"Besides, no nimbus or aureole was to be placed around the head of any saintly person represented." "Apostles must not be distinguished by keys, swords, pilgrims' staves, escallop shells, &c.; nor are any to be clothed in the costume of the Roman hierarchy. No representation of God the Father, of the Holy Trinity, or of the Holy Ghost, or of the Virgin Mary as the 'Mother of God.'"

At this time this was carried so far that no direct representation of the Saviour was contemplated. The paintings were to be "direct historical representations of a series of scenes from the Bible, treated according to the laws of arrangement and design necessary under the technical conditions of glass painting, but not in any way symbolical representations. "This," the specification went on to say, "will not prevent your representing Scripture characters as noble figures, designed in a true spirit of reverence for their greatness and holiness."

The importance of these stipulations will be estimated when prevalent ideas regarding the imitation of old art are considered. They were addressed, as I have remarked, to Roman Catholic artists; but they would have been as necessary had they been so to Protestant glass painters, who consider it absolutely necessary to repeat with fidelity the designs of our Roman Catholic ancestors. Symbolic figures in all religions, pagan or Christian, were destined to be readily recognized by the illiterate. They were distinguished by characteristic form, which was never varied, by appropriate colour, and by the presence of insignia, such as peculiarities of costume, swords, keys, staves, instruments of martyrdom—even portions of their own persons, presented to the spectator apart from their proper places in their own bodies—as St. Stephen in the dress of a deacon of the Roman Catholic Church, with one stone of martyrdom on his head, another on his shoulder—St. Paul with a sword—St. Peter with keys—St. James with a pilgrim's staff, a cloak, cape, wide brimmed hat, and escallop shells—St. Agnes with a lamb—St. Catherine with a wheel carried about with her whatever she may be doing—St. Sebastian stuck through with arrows, yet in placid

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dignity of demeanour—St. Lucy presenting her own eyes on a dish—St. Denis carrying his own head in his hands.

The motives for these methods of representation are perfectly intelligible, when people could not read; they were partly to be considered works of art, but they were still more hieroglyphics. The combination of these symbolical figures into groups was necessarily regulated by laws proper to such symbolism, by existing religious ideas, by the state of art. Such compositions of figures were not pictures in our sense of the word.

I would also press upon you the fact that such representations when found in glass painting, were not specially conceived in relation to that art; there was not one method of treatment for pictures on windows, and others for pictures on walls, panels, or vellum. The distinction now sought to be made between pictures and glass paintings was wholly unknown to the old masters, and no difference whatever existed in the character of these different works of art, beyond certain practical necessities arising from the materials used, which the glass painter always did his best to overcome, so as to bring his art into the closest relation to the painting of his time. If the figures on his glass were in one plane, so were the figures in historic pictures, if they were grouped above each other, so were they in pictures; when, however, the invention of perspective enabled the artist to place the figures in his pictures in true relation to each other, the glass painter instantly adopted the new science; when, in painting, gold grounds gave place to blue backgrounds, and these were afterwards varied by the introduction of landscapes and buildings, the glass painter imitated the same effects; at last, painting becoming more and more realistic,—penetrating, so to speak, deeper into the arcana of nature, representing atmospheric effects, play of light and shade, wonders of chiaroscuro,—glass painting once more tried to follow; but the limits of its powers were passed, and it withered, I may say, died in the attempt. Its decay was hastened by another cause, symbolism in art became useless as literature advanced. Glass painting could only exist whilst fine art was in a special manner monumental in its character; when it became realistic, its general influence on all the decorative branches of art gradually ceased, and in our own time, when it has become absolutely naturalistic, the connection between the decorator, the pattern drawer, and the artist, has almost entirely disappeared. The Committee, having no intention of restoring ancient symbolisms, still had to consider how the conditions which were established were to be harmonized with the ancient structure. If they could not be so in the letter they might be so in the spirit. I would request you, in the first place, to observe

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that, in considering this important part of the subject, the groups of figures should be separated in the mind entirely from those associated with architectural ornaments. The human figure, or figures of animals, in relation to architecture, must always be considered under two separate heads, those which are entirely conventional and ornamental and those which form parts of representations of real events. In the first category we must place all the imaginary creations with which the ornamentist enlivens his world of fancy—creatures of poetic fancy, sometimes of distorted and tasteless fancy—sometimes, and especially in Gothic ornament, of a pure love of fun. In ornament all must be fanciful if we would be consistent; but real scenes, and real actors in those scenes, cannot thus be dealt with, and great errors in criticism have been perpetrated by those who overlook this important distinction. We cannot, with any pretence to reverence of feeling, represent the patriarchs and prophets of old, our Saviour and his disciples in the spirit of mere decoration. If they are to be represented at all, we must do our best, in harmony with our feeling of love and reverence for their goodness and holiness. On the same principle, we in the present day cannot return to symbolical representations, or copy old forms of art which no longer appeal to our sense of veneration, but which are in fact wholly opposed to our idea of the appearance and character of those persons. I do not hesitate to say that the imitations of the mediæval representations of the Lord, and the most holy persons of the sacred Scriptures, are offensive to right feeling; and the assertion that they are to be considered as mere decorations is entirely contrary to the ideas of the old masters themselves, who unquestionably were actuated by pious motives, and did what they could, and would have done infinitely more, if they only had possessed the power.

If these views of the subject be true, and they are supported by the practice of the greatest artists of all great periods, it was necessary to separate the ornamental accessories from the figure subjects—to deal with the first as a framework, which might properly be in the style of the fourteenth century, but to treat the subjects framed in a spirit of reverence for the persons represented, and with a desire to instruct and elevate the taste of the people. It is perfectly obvious that no imitations of mediæval art could do this; they might have gratified a merely sensuous feeling for colour, or a pedantic attachment to old forms, but as representations they could have touched no chord of sympathy in the people generally: I am, indeed, entirely persuaded that they would have done more harm than good. Living in Scotland, we could hardly forget that the Scottish people rooted out old symbolisms, even at the cost of their most beautiful religious edifices.

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In considering this question, which is of the highest importance, we may ask ourselves not only what has been the practice of the great masters in art of bye-gone times, but what is the practice of the best living artists? Let us recall the frescos by Maclise, Dyce, Cope, Ward, and others, in the new Palace of Parliament. Do we find that, because the building to be painted with monumental pictures is in the style of the architecture of Henry VII., the pictures lately executed on its walls are designed and drawn in imitation of the painting in England of that monarch's time? Certainly not,—nor have the sculptors, whose statues of British heroes and statesmen adorn its halls, allowed the pretence of adherence to style to fetter them. Both painters and sculptors have conceived and executed these important works in harmony with the ideas of the age in which we live, and for this we may be grateful. On the other hand, the windows in the same great national edifice are executed in imitation of the old manner contemporaneous with the building. Could we find a more striking illustration of the separation which has taken place between modern fine art and glass painting than this? There is not an approach to sympathy between them. Either the artists or glass painters must be wrong, they cannot both be right. But instead of a modern let us suppose the case of an ancient edifice, and that in the progress of a love for monumental art Mr. Maclise and others of our great painters should be called upon to decorate it with frescos, can any one imagine that these distinguished men casting aside entirely their powers as poets, designers, draughtsmen, and colourists, would paint in the barbarous style of the thirteenth century because such was the style of the architecture? They would do no such thing, they would leave it as all such work unhappily is left with us to the mere decorator, for we differ in this both from our ancestors and our most civilized contemporaries. Our artists would no more think of such a sacrifice of themselves and of true principles than did Raphael and Pinturicchio, in the Gothic Cathedral of Sienna—than did Luca Signorelli, in his immortal works in the Gothic Cathedral of Orvieto. On the contrary, looking around the great old work of architecture, they would say—"Here all is noble, dignified, monumental; so shall our works be in the spirit of this great architectural work, and of the age in which we live." There is no other principle worthy of the consideration of rational men.

That our ancestors thought in this way, there can be no doubt whatever. In our ancient Gothic fanes we find that solid wall spaces suitable for paintings gradually disappeared, being more and more widely pierced with windows, and these spacious mullioned openings

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became more and more dealt with as pictures. One of the most remarkable instances of this in Europe is the Chapel of King's College Cambridge, filled (with one modern exception) with storied glass by artists of Brabant, in the Italianized manner which distinguished them in the sixteenth century. These glass paintings in the style of the Revival, are placed in windows of perpendicular Gothic, and were as certainly regarded by our ancestors in the light of pictorial illustrations as the frescos of the Sistina.

With these examples before them, with the question—if the windows are to be storied windows, if, as representations of past events of the highest interest and importance, they are to address themselves to the intelligence and thinking powers of the people of Scotland—how are they to be designed?

It is quite obvious that any error in solving this important question would have exposed the Committee to grave reprehension; that to have peopled our windows, as is the practice in England, with mere repetitions and imitations of the symbolical figures of the mediæval Romish system would have been justly condemned. In England, throughout the length and breadth of the land, the legendary images of Rome have been adhered to in modern windows, and there is nothing to indicate the difference between a Protestant and a Roman Catholic Church; in too many instances, the paramount object appears to be to exclude Protestant ideas.

Having thus endeavoured to explain to you the prevalent ideas which guided the Committee in the selection of subjects, and the method of dealing with them, I proceed to read some further portions of the specification which was forwarded to the artists, after being translated into the German language:—"The next point for consideration is the necessity for treating the glass paintings in harmony with the architectural character of Glasgow Cathedral. On this point the wishes of the subscribers can only be expressed in general, it may be in vague terms. To lay down a detailed rule of treatment would be to assume the province of teachers, inconsistent with their resorting to you for artistic assistance. At the same time, and disclaiming any offensive dictation, it is right to express to you, as clearly as possible, the impression which pervades in a greater or less degree the minds of the subscribers. The subjects to be represented in the windows, with a few exceptions separately specified, may be considered as agreed upon. It is the general wish that the figures should be as large as the size of the spaces will admit, consistently with the principles of pictorial composition. You will perceive, from the various lithographs sent to you, that the windows proposed to be filled with painted glass

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have their openings divided from each other by masses of stone work, or very heavy mullions; this circumstance would render it highly objectionable to spread a single subject across the whole window, as was the manner in many old windows in Germany, and elsewhere, of the fifteenth and sixteenth centuries. On the contrary, it is desirable that in each window there should be represented as many distinct subjects as there are openings, each being confined within the limits of a single opening, although they may well bear a relation to one another. Thus, if the window in its lower part contained three principal openings, it would be preferred that the painted glass in it should represent either three different actions of one narration, which narrative the entire window might be said to represent, or three events in the life of or relating to the principal personage, or three illustrations of the main subject of the entire window. This may be explained by supposing that the story of the Good Samaritan was selected as the principal subject of a window. The first event in the story is the falling amongst thieves,—the next is the passing by of the priest,—then follows the passing by of the Levite,—lastly, the aid rendered by the Samaritan. It is obvious that there are four subjects in this story, any three of which may be selected for the window; thus, the Good Samaritan tending the wounded man might be placed in the centre opening, the inhuman Levite in one of the others, and the hypocritical priest in the third; and so each light of the window would be occupied by a complete and separate subject, which together form one story—an arrangement analogous to that of the ancient tryptich, or early altar painting, having folding doors or wings. It is also desirable that a certain degree of severity should be imparted to these glass paintings, in order to insure harmony between them and the Cathedral."

That is to say, that the glass paintings should be designed and painted on the principles of monumental art, as the only means of really dealing with them in the spirit of the architecture. The windows as executed agree with the terms of the specification, with one exception only. The general design is architectonic and in accordance with the principles and practice of monumental art; the groups are harmoniously balanced and skilfully composed, so as to avoid perspective effects, which might justly be objected to. Singular ability is manifested in the dexterity with which the compositions are compressed within narrow spaces without crowding. It is not desirable that glass painting should be treated absolutely upon the principles of bas-reliefs, as some insist; glass painting as an art is allied to painting, not to sculpture. The pretence that all the figures in a glass painting must be placed on one plane is as opposed to the practice of the old masters

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of this art as a similar arrangement in wall painting would be. In the oldest examples of glass painting existing figures are placed behind each other, indicating several pictorial planes and a rude perspective is attempted. The whole of this subject is illustrated in the works of succeeding artists for generations. It is manifest that they thought differently from those critics with a slight knowledge of art, and without cultivated taste or sentiment, who revel in theories on this and kindred subjects and imagine that they have discovered fundamental laws, when in reality they have hardly penetrated beyond the outskirts of those which genius and true taste have mastered. These pretended laws are convenient pegs on which incapacity can hang imperfect practice, and as by them all the real difficulties of art are got rid of, they are naturally thrust forward upon all occasions as rules which it is ruin to depart from. It is very different with the artist of genius, who knows that if art has laws it has freedom also, without which it would die.

The backgrounds differ from the terms of the specification, in which it was stipulated that they should be simply a stiff coloured ground, with or without diaper, as might be expedient. This has been realized in three of the great windows, in those of the transept, and in the small windows at the east end. The artists did not carry out the principle in the others,—happily so, I now think; and we owe to their different opinion and skill some of the finest examples of background ever produced in glass painting. With regard to the ornamental accessories as I have already remarked, these being carried to great perfection in mediæval times, the artists could not do better than adhere to the principles of the old ornamentists. The Cathedral itself exhibiting the transition from Early English towards Decorated, the latter style of ornament was selected, the more so that it offered this important advantage, that the canopies appropriate to it permit the extensive use of white glass, and the consequent admission of a sufficiency of light for the comfort of the congregation. In a climate like ours this was important.

Again, to quote from the specification on the subject of ornament, the following expressions were used:—"It is wished to refine and develop, as much as you think necessary these forms and details to bring them into harmony with the rest of the composition of the windows; it being desirable that they when completed, should in no respect be mistaken for ancient works of the end of the thirteenth century or early part of the fourteenth, or for copies or servile imitations of such works; but that they should manifestly appear to be excellent works of the nineteenth century, harmoniously adapted to the general character of an edifice so ancient as Glasgow Cathedral."

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It is obvious that on this point there may be no end of discussion between parties who take extreme views. The love of precedent in the British mind is so strong, and so completely fetters the intelligence of many people on almost all subjects, that independent action is with them heresy. But, as I have already remarked, the mass of the Scottish people are tolerably free of this in respect of art, and happily so, I venture to think. With regard to the execution of the glass, the following remarks were made:—

"There is yet another point of considerable importance, which it is desirable to bring under your attention. This relates to the execution of the painting. It is a common objection in this country to the glass paintings executed at Munich, that the glass loses its brilliancy, and much of its power, by the practice of subduing the high lights, either by soft shading, or by enamel ground at the back of the glass. This practice is defended by the desire of imparting to the modern too pellucid material somewhat of the substance which an imperfect manufacture and age combined have imparted to the ancient material. But nothing can compensate for the want of clear lights and consequent brilliancy. It should be remembered that the smoky atmosphere of Glasgow will soon make a deposit upon the glass sufficient to correct all thinness."

It may thus be seen that the too great translucency of modern glass was not forgotten, but it was preferred to accept this defect rather than to allow it to be corrected by a process common in all modern glass painting, which in an atmosphere like that of Glasgow would have led to disastrous results, as the floating filth of that atmosphere would inevitably adhere to the enamel obscuring the glass, and would entirely destroy its brilliancy. Such an accumulation of filth is wholly different from the patina produced in the course of time on old glass paintings, which mellows and enriches them without injuring their brilliancy. I may state that experience has completely verified these anticipations of the specification.

A second specification contained remarks upon our climate, the force of the wind, as observed by Professor Nichol, and the mechanical precautions to be taken; the effect of the atmosphere and of its floating impurities on the stone-work of the Cathedral, and the probable effect on the glass; the colour of the stone-work and wood-work, with minute statements regarding the general design and form of the building; together with remarks on the progress of ideas which is observable in the design of the stone-work of the windows. The specification then proceeded to describe minutely those principles regarding the colour and harmonious arrangement of the windows, which, having

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already adverted to, I need not repeat here. Whilst stipulations were made for the harmony of the windows, the comfort of the congregation was not forgotten, and provision was made for a sufficiency of light.

Lastly, a third specification was provided, with designs for the general forms of the Heraldry. This subject alone was a work of considerable labour, and led to a voluminous correspondence.

No part of the onerous duties and responsibilities of the members of the Committee was of higher importance than their selection of artists to design the windows. I have endeavoured to bring clearly before you their ideas regarding the figure parts of the windows, which were to be original works, exhibiting the highest characteristics of fine art, in composition, form, expression, and colour. They judged that such designs as they required could be made only by artists of eminence; they did not believe, nor was there any reason for believing, that they could get such designs from glass painters either at home or abroad; there never has been any question of the relative merits of the British and Foreign glass painters, as it never was intended to place the commission in the hands of glass painters only of any country. The object of the Committee was to place the design of the windows in the hands of artists distinguished by the importance and excellence of their works, accustomed not only to design as painters, but to design in harmony with the technical conditions of glass painting, or in association with one or more artists familiar with these, and who could regulate their designs accordingly. In addressing a Glasgow audience I feel it to be quite unnecessary to enter into any explanation of the importance of designing in accordance with the practical conditions of reproduction. Every one here is probably familiar, if not with these, at all events with the principles involved, and will, therefore, readily appreciate the importance of the selection of artists familiar with the only conditions which could render their services available.

We may here recall for a moment the principal duty imposed upon the members of the Committee: it was to expend the funds placed in their hands, after due inquiry, in selecting the finest works of art procurable. Those funds were not confided to them for experimental purposes. They could not in the exercise of the functions with which they were entrusted make novel experiments, and endeavour to promote a union between the eminent artist of this country and the practical glass painter which does not at present exist. After a careful examination of numerous works by practical glass painters in many churches, having decided against the choice of similar works, and having searched in vain for instances of windows of modern date in which the desired

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union existed, they were compelled to look elsewhere. There was at that time only one example in Great Britain of a really fine work of art in glass designed expressly by a modern British artist of distinction. This window was carefully examined and admired, as it pre-eminently deserves; but whilst it was designed in England, it was executed on glass at Munich. It therefore could not be considered an example of British art for the guidance of the Committee of the Glasgow windows. It was also ascertained that the cartoon of that window cost £500, altogether apart from the glass, which was separately contracted for. It was out of the question to contemplate such a scale of price as this. Without for a moment impugning its justice, the merit of the design being considered, and the value happily attached to the works of our eminent artists, such a scale would have doubled the cost of the Cathedral windows.

The funds at the disposal of the Committee were liberally granted by the subscribers, but nothing approaching such an expense as this could reasonably have been proposed. The window in question was, and so far as I know still is, a solitary instance of so great a work on which a distinguished British artist has been employed; but if the Glasgow windows were to be executed within a reasonable time—within the lifetime of this generation I may say—not one but many artists were required; ten artists have actually been employed, of whom six at least enjoy a European reputation—three of whom are amongst the foremost artists of our century. But besides the advantage of obtaining the aid of so many artists of eminence, there existed at Munich a great organization by which they and the executants of their designs, the glass painters, could be brought into complete and harmonious relationship. The paramount advantages of this state of things must be obvious, could the Committee undertake to bring into such an intimate relationship artists and executants in this country for the first time, dealing of necessity separately with each. Had such a combination been at all possible, it is obvious that they must have delegated their functions to some one as practical director, capable of organizing and directing such a scheme. In fact, they could hardly have stopped short of organizing a great glass painting establishment on the same principles as those carried out in practice at Munich,—with its Director, the Professor of Fine Art in the Royal Academy; its Inspector, the Chevalier Maximilian Ainmiller, Architectural Painter; and its Instructor in Technical Processes, the artist Leonhard Faustner. It may be remarked in connection with this subject, that the Royal Commission, with the late Prince Consort at its head, appointed to consider how art could be promoted in this country in connection with the

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completion of the new Palace of Parliament, aided by the public funds, backed by Parliament, which cordially promoted the projects of the Commissioners, and having plenty of time at their disposal, did not place the design of the windows of that great national edifice, so far as the figure portions are concerned, in the hands of the artists who have designed the frescos, as would unquestionably have been done in France or Germany, or in former ages in this country also, in an edifice of such great national importance. Is it probable that a private Committee could do that which so powerful a Commission did not achieve?

The three most eminent artists employed in designing for the Glasgow Cathedral windows are Heinrich Von Hess, from whose cartoons the north transept window was executed; Moritz Von Schwinde, who prepared the designs for the great west window and the great south window; and Johann Von Schraudolph, who is the author of the beautiful east window. Several of the windows of the aisles have been designed by George Fortner, an eminent artist, of great experience as a designer for glass painting, and author of several of the windows for the Cathedrals of Cologne, Ratisbon, and Basle. Alexander Strähuber, a well-known designer of religious subjects, is the author of some of the most beautiful windows in our Cathedral. The Professor Siebertz, Franz Fries, a pupil and follower of the great artist Kaulbach, and Henry Ainmiller, have also contributed important designs. The Chevalier Maximilian Ainmiller, Inspector of the Glass Painting Establishment at Munich, and an architectural painter of great eminence, acted as the practical chief of this able and distinguished staff of designers, and watched over the production of their designs on glass by the three artists and glass painters, Leonhard Faustner, Heinrich Burkhardt, and Theodosius Mayr, who are not glass painters only: they are all educated artists, and the two first are celebrated as enamel painters. The business part of the Glasgow Committee's duties have all been transacted with one of these gentlemen, it has been unnecessary to enter into correspondence with the different artists, or to enter into any transactions except with one person, the Chevalier Maximilian Ainmiller. Men of business will estimate the value of this fact. All has been transacted with a regularity, a correctness, and a promptitude beyond all praise. Not a difficulty has occurred. So sensible has the Committee been of this, and of the methodical administration of the department at Munich, that on the occasion of a visit of the King of Bavaria to Nice, the late Duke of Hamilton, in the name of the members presented an address to His Majesty, expressive of their high appreciation of the

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works of art, and of the zeal, ability, and courtesy of the distinguished artists engaged upon them.

I would now refer briefly to the arrangements of the subjects of the windows. In the nave they are selected from the Old Testament, with certain exceptions which illustrate the connection between the Old and New Testaments. The subjects begin at the north-west corner of the nave, according to ancient practice, and the first is the Expulsion from Paradise, as the commencement of man's actual state in the world. The subjects follow each other in the order of Bible chronology, the Old Testament series being completed in the eighteenth window, in the south-west angle of the nave. The great west window contains, in four divisions, four great national events in the history of the chosen people,—the giving of the law, the entrance into the promised land, the dedication of the temple, and the captivity at Babylon. The north transept window contains six figures of prophets, which are amongst the noblest designs of the gifted Heinrich Von Hess. The south transept window illustrates the connection between the two Testaments, containing the types and antitypes of the Saviour of mankind. Two small windows, one on each side of the principal entrance, are filled with compositions representing the training up of the young in the fear of the Lord, worship, and praise; the significance of these ideas in this part of the church will be readily understood. The ancient choir, now the church, opens up ideas of Christian faith and doctrine; it contains ten noble aisle windows, the subjects in which represent the teaching of Christ,—his lessons of humility, mercy, forgiveness, love, and faith; and they terminate with his triumph over sin and death; the last window reverses the sentence enforced in the first. The small windows at the east end contain figures of the Apostles who promulgated the Saviour's doctrine, and the great east window the Evangelists who wrote his history and transmitted to us his teaching.

Such is a brief account of this cycle of Bible history, which is quite unequalled in its completeness in any church in the world, and wholly unapproached in the grandeur with which patriarchs, kings, prophets, apostles, evangelists, angels, and our Lord himself, have been represented in painted glass, since the last great age of glass painting.

There is still a conflict of opinion regarding the merits of these windows. Some express a warm admiration, some a very opposite feeling. I may be permitted to remark, that there is perhaps no branch of fine art which requires more patient study and investigation than glass painting, to be critically understood. Some who devote time and attention to this study, in their admiration of the works of the past,

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would limit all human efforts to the imitation of these; like the ancient Egyptians, they would bind art for ever in one unchanging routine of practice. This certainly gets rid of many difficulties which beset the path of the artist who supposes, with the great Masters of old, that he must embody high thoughts in fitting forms, and substitutes for such aspirations mechanical skill of mere imitation. Other students of old glass, equally admiring its beauties, and the taste and skill of the old artists who executed it, see in it the guide to new triumphs of invention. The members of these two schools of criticism look at our Cathedral windows with very different eyes; and we may anticipate from both sides new assaults or further expressions of praise. Other influences actuate critics. The very high churchman, for instance, who would restore mediævalism in everything, is certain to attack modes of representation which break away so entirely from the ideas which to him are articles of faith. The imitator of old glass painting is certain to attack principles which, if they become prevalent, must destroy his occupation, or compel him to try and become an artist. Beyond the pale of these is the general public. Educated people, when looking on the windows, experience a new sensation; for they appeal to them, as works of art, to their sense of beauty, their sympathy with true and characteristic expression, their interest in what belongs to humanity,—instead of claiming notice as mere ornaments of agreeable forms and combinations of colour, or (if representing human actions) as works of art which must be endured because they are only glass painting.

As to the working classes, who have been as much thought of as any other members of the community, the interest with which they regard the windows never could have been excited had they been presented with imitations of the conventional figures of mediæval art; they are not educated down to these, and in all probability would have regarded them as merely ridiculous.

In this great work, which I have endeavoured to describe, the Committee have reverted to old principles, which I earnestly hope may finally prevail in all art; and whatever the defects of the windows, as compared with the great productions of the old Masters, when compared with the best of our own time, they are wholly unrivalled in excellence.

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A Practical Application of Dialysis. By Mr. Alexander Whitelaw.

Read February 24, 1864.

The discovery of Dialysis, by Mr. Graham of the Mint, is perhaps the most important event in connection with chemistry that has marked the last two years. There are many in this room to whom Mr. Graham's elaborate investigations are no doubt familiar; but as there may be some present whose studies do not lie in this direction, I will, even at the risk of being tedious, give a short outline of the Master of the Mint's experiments, so that the process hereafter to be described may be the better understood.

About seventeen years ago Mr. Graham commenced his investigations into the phenomena of liquid diffusion, and has continued his researches up to the present time. During that period he has contributed five or six valuable papers on the subject to the Royal Society. His first experiments were conducted after the following fashion:—He took a glass jar, which he nearly filled with water, then placed in this vessel very carefully a small vial or cylinder filled with the liquid to be examined. This arrangement was allowed to stand for some hours or days; the interior vessel was then removed, and the liquid in the outer vessel evaporated, or otherwise treated, so as to determine how much of the salt or other substance had become diffused into it.

After a series of experiments, very carefully conducted, Mr. Graham found that different substances differ very materially in the rapidity with which they diffuse, as the following table will show:—

Vial Diffusion.

Chloride of Sodium,	58·68
Sulphate of Magnesia,	27·42
Nitrate of Soda,	51·56
Sugar,	26·74
Gum,	13·14
Albumen,	3·08

It was found that from a solution of salt containing 20 per cent., about 58½ grains became diffused in a given time, while with a similar solution of albumen only 3 grains diffused into the outer vessel.

Mr. Graham continued his experiments with graduated cylindrical

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jars. These jars he filled ninety parts full of water, and then introduced ten parts of the solution to be examined, by means of a pipette, to the bottom of the jar. After allowing the process of diffusion to go on for a time, he examined the different strata of the contents of the jars, and determined how much of the substance under examination each layer or tenth of the vessel contained. By these experiments he found that, after hydrochloride and the allied hydracids and some few salts, common salt was one of the most diffusible substances. It rose to the top layer of the jar with comparative rapidity, and to a considerable extent, while albumen and similar substances rose only a little way, and in very small proportion.

After continuing his experiments, Mr. Graham found that generally crystalloid substances were more readily diffusible than non-crystalline, or what he termed "colloid," bodies. Albumen, gum, gelatine, starch, jelly, &c., belong to the latter class. Continuing his investigations, he found that with crystalloids the diffusive action also took place into and through soft, solid, colloid substances, holding water in a loose state of combination—such as jelly, for instance; but he likewise discovered that such substances completely, or almost completely, arrested the diffusion of colloids, such as albumen and gum. He found that the merest film of a colloid in the solid state arrests the progress of colloids in solution. A sheet of well-glazed letter paper has the effect; and the experiment may easily be tried by wetting thoroughly a sheet of thin French note paper, and laying it on the surface of water contained in a small basin, depressing the paper in the centre, to form a tray. If into this tray we place a solution containing 5 per cent. of sugar and 5 per cent. of gum, and allow the whole to stand twenty-four hours, we shall find that at the end of that time nearly three-fourths of the sugar shall have passed through the paper into the water, and scarcely a trace of the gum. This led to the construction of the "Dialyser," an instrument consisting of a hoop of gutta-percha, with a piece of animal membrane or parchment paper stretched over it. With this arrangement he continued his researches, and obtained some very curious and interesting results.

The following are the results of dialysis on a crystalloid and a colloid body, a 10 per cent. solution being used in both cases:—

Gum Arabic, ...	0·029
Common Salt, ...	7·500

Proportional diffusion through parchment paper in twenty-four hours of various substances:—

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Common Salt,	1·000
Picric Acid,	1·020
Ammonia,	·847
Cane Sugar,	·472
Extract of Logwood,	·168
Catechu,	·159
Extract of Cochineal,	·051
Gallo-tannic Acid,	·030
Purified Caramel,	·005

Others of Mr. Graham's results are most interesting, but do not come within the scope of this paper; and it is enough for me to have given a rough outline of this very important discovery of a property of matter which evidently plays an important part, not only in the animal and vegetable systems, but also in the earth's crust.

The diffusive power possessed by all liquid substances is so similar in character to volatility that we may fairly reckon on a class of analogous analytical resources to arise from it, and that by means of dialysis certain substances may be at least partially separated from each other. I have availed myself of this fact in the process, to which I will shortly direct your attention. In the meantime it will be necessary to consider the nature of flesh, as it is with this substance that we shall have to deal; and I have again to crave the indulgence of the Society while I direct their attention to a subject which is not new, but which is necessary to be considered before my process can be properly understood.

Flesh, as the following table shows, is composed of—

Water,		78·0
Fibrine, vessels, nerves, and cells,		17·0
Soluble Matter	Albumen,	2·5
	Acids and bases, organic and inorganic chlorides, and kreatine,	2·5
		100·0

When finely chopped flesh is digested with water and pressed out, and the process repeated till the soluble matter is all removed, there is left a white fibrous residue, consisting of muscular fibre, cellular tissue, vessels, and nerves. This residue, when boiled in water, is, like the water in which it has been boiled, tasteless, or has a slightly sickening taste, and even dogs reject it.

All the savoury constituents of flesh are contained in the juice, and may be extracted by washing. When the watery infusion of flesh is heated gradually, the albumen first separates at a temperature of 133° Fahr.; then, when the heat has been increased to 158°, the colouring matter of the blood coagulates, and may be removed by filtration. The

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liquid is now clear, and of a pale yellowish colour, and has an agreeable and aromatic taste. When evaporated at a gentle heat it becomes gradually darker coloured, and acquires the flavour of roast meat. When dried, there is obtained a brown somewhat soft mass, amounting to from $2\frac{1}{2}$ to 3 per cent. of the original flesh. If the albumen and colouring matter are not separated, the residue will amount to 5 per cent. of the weight of the original flesh. This extract is soluble in cold water, and when dissolved, with the addition of a little salt, in about 32 parts of hot water, it gives the water all the properties of an excellent soup. The flavour of the dry extract is intense. This extract of flesh, freed from the matters coagulated by heat, is composed of kreatine, kreatinine, and a number of organic and inorganic salts and acids; but the greater part of it consists of uncrystallizable bodies, the properties of which have not been, so far as I am aware, yet studied.

"The juice of flesh," Liebig says, "contains beyond a doubt all the conditions necessary for the formation of muscle. In the albumen of this fluid we have the substance serving as transition-product to the fibrine of flesh, and in the other substances the material required for the formation of cellular tissue and nerves."

It is thus easy to explain the effect of soup. Soup is the medicine of the convalescent. No one estimates its value more highly than the hospital physician, for whose patients soup, as a restorative agent, cannot be replaced by any other article of the Pharmacopœia. Its revivifying action on the appetite, the digestive organs, the colour, and general appearance of the sick is most striking.

We can now understand the loss of nutritive value in salted meat. When dry salt is sprinkled on fresh meat, it is found, after a few days, swimming in brine. Fresh meat, as we know, contains more than three-fourths of its weight of water, which is retained in it like a sponge. But flesh has not the power to retain brine to this extent, and in similar circumstances it absorbs only about half as much saturated brine as of water; so that, under the action of salt, flesh allows a portion of its water to flow out. This expelled water is, as we would naturally expect, saturated with the soluble nutritive and savoury ingredients of the flesh; it is, in fact, juice of flesh-soup, with all its valuable and restorative properties.

In our large curing establishments very considerable quantities of this brine are produced and thrown away as useless. This is the material to which I have applied the process of dialysis, I think with success, for the removal of the salts of the brine, and for the production, at a cheap rate, of pure fresh extract of meat.

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My process is as follows :—The brine, after being filtered to free it from any particles of flesh, or other mechanical impurities it may contain, is subjected to the operation of dialysis. The vessels or bags in which I conduct this operation may be made of various materials, and of many shapes; but whatever may be their material or shape, I call them "dialysers."

The following apparatus will be found to answer the purpose:—A square vat, made of a framework of iron, filled up with sheets of skin or parchment paper in such a way as to be water-tight, and strengthened, if necessary, by stays or strips of metal. The sides, ends, and bottom, being composed of this soft dialysing material, expose a great surface to the action of the water contained in an outer vat in which the dialyser is placed. I find a series of bladders fitted with gutta-percha mouth-tubes and plugs, and suspended in vats of water from poles stretching across the vats—a very convenient arrangement. I also can employ skins of animals either as open bags or closed, and fitted with stop-cocks, or bags of double cloth, with a layer of mucilage or soft gelatine interposed between them. Other arrangements will readily suggest themselves, and may be adopted according to circumstances.

But supposing, then, that we take the bladder arrangement,—which I think will be found practically the best for our operation, being cheap, easily managed, and exposing a great surface to the dialytic action,—the bladders are filled with the filtered brine by means of fillers, and hung in rows on poles across, and suspended in, vats of water. The water in these vats is renewed once a day, or oftener if required; and I find that actually, at the end of the third or fourth day, according to the size of the bladders employed, almost all the common salt and nitre of the brine have been removed, and that the liquid contained in the bladders is pure juice of flesh, in a fresh and wholesome condition.

TABLE SHOWING THE PROGRESS OF THE DIALYTIC OPERATION ON A BLADDER CONTAINING 1½ GALLONS.

Strength of brine at first,	40°
After 24 hours' immersion,	15
,, 36 ,,	9½
,, 48 ,,	7
,, 72 ,,	4
,, 84 ,,	2½

The juice of flesh, as obtained from the "dialysers," may now be employed in making rich soups without any further preparation, or it may be concentrated, by evaporation, to the state of solid extract of meat. I have also had prepared more carefully a soup from the brine,

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to which I would direct attention. The brine used is from one of our most respectable curing houses, and is perfectly pure and wholesome.

The liquid from the dialysers may be treated in several ways. It may be evaporated in an enamelled vessel to a more or less concentrated state as to dryness, and in these various conditions packed in tins or jars for sale; or it may be concentrated at a temperature of 120° by means of a vacuum pan, or other suitable contrivance, so as to retain the albumen and other matters in a soluble form; or I take the more or less concentrated liquid extract, and along with flour use it in the manufacture of meat biscuits. These meat biscuits I pack in a powder made from the biscuits themselves.

The products I have named are all highly nutritive, palatable, and wholesome, and admirably adapted for the use of hospitals, for an army in the field, or for ship stores.

The dialysis of brine may be conducted in salt water, so as to remove the greater portion of its salt, and the process completed in a small quantity of fresh rain or other water. In this way ships at sea may economize their brine, and so restore to the meat, in a great measure, the nutritive power that it has lost in the process of salting.* I find that, using a very small bladder, brine at 40° Tw., dialysed in sea-water, lost in three days 33° Tw., and was reduced to 7°, the average strength of sea-water being about 6° Tw. = spec. grav. 1·030.

Thus, then, I obtain extract of flesh at a cheap rate from a hitherto waste material. Two gallons of brine yield 1 lb. of solid extract, containing the coagulated albumen and colouring matter. For the production of this directly from meat, it would take something like 20 lbs. of lean beef.

The quantity of brine annually wasted is very great. In Glasgow alone, I believe I am very considerably under the truth when I say that 60,000 gallons are thrown away yearly.† If we estimate 1 gallon as equal to 7 lbs. of meat in soup-producing power, this is equal to a yearly waste of 187 tons of meat without bone. Estimating it as worth 6d. per lb., this is equal to a loss of £10,472. Over the country the waste in this way must be heavy. In the great American curing establishments the brine wasted must be something enormous, as I find that in eight of the Federal States 4,000,000 pigs were slaughtered and cured last season.

* Liebig says, of 3 cwts. of meat 1 cwt. may be rendered unfit for the vital process by salt.

† Since writing the above, I find that the quantity of brine produced in Glasgow was very much under-estimated, and that probably 180,000 gallons is nearer the truth.

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I shall now conclude by reading one or two extracts from Gregory and Liebig bearing on this subject.

Dr. Gregory says, in his *Handbook of Organic Chemistry*—

"If, in countries like Australia, Buenos Ayres, &c., where cattle are killed for their hides and tallow alone, the flesh were thus exhausted, and the soup evaporated to a soft extract, then the true extract of flesh would be obtained at a cheap rate, and furnish a valuable article of food, one part of which is equal to nearly thirty of fresh meat. This is to be carefully distinguished from the portable soup in hard gelatinous cakes, which consists chiefly of gelatine, and often does not contain one-tenth of true extract. Gelatine cannot yield blood, and is worthless as food, except perhaps in very small proportion. The extract of meat is always soft, and does not gelatinize."

In Liebig's *Familiar Letters on Chemistry* there is a note at page 426, in which he says—

"If the price of the extract should be found not to exceed 3s. per pound, it would certainly become a most profitable commodity. In Geissen, without reckoning the cost of preparation, the extract of meat cannot be produced for less than 6s. to 7s. 6d. per pound of meat alone."

The note also says—

"True extract of meat is never hard and brittle, but soft, and strongly attracts moisture from the air."

At page 422 of the same book occurs the following passage:—

"Sagacious and experienced physicians, and of these especially Proust and Parmentier, have long ago endeavoured to obtain a more extended application of extract of meat. 'In the supplies of a body of troops,' says Parmentier, 'extract of meat would offer to the severely wounded soldier a means of invigoration which, with a little wine, would instantly restore his powers, exhausted by great loss of blood, and enable him to bear being transported to the nearest field hospital.' 'We cannot,' says Proust, 'imagine a more fortunate application. What more invigorating remedy, what more powerfully acting panacea, than a portion of genuine extract of meat and a glass of noble wine! The most recherche delicacies are all for the rich. Ought we, then, to have nothing in our field hospitals for the unfortunate soldier, whose fate condemns him to suffer for our benefit the horrors of a death-struggle amidst snow and the mud of swamps.'

"Now, when science has made us better acquainted with the nature of the juice of flesh, it appears to be truly a matter of conscience again and again to recommend to the attention of governments the suggestions of these noble-hearted men."

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Supplementary Note.

There is another modification of this process, applicable to ships at sea, by which the quality of the salt meat supplied to the men may be much improved.

The salt meat is placed in a dialytic bag, or other arrangement, and the bag filled up nearly, but not quite, full of brine from the beef barrels. The dialyser is then placed in sea-water, and the process allowed to go on for several days, till the meat and brine are sufficiently fresh for use, or till the brine in the dialytic bag is within one or two degrees of the same strength as sea-water. In this way, as the brine becomes freed from salt, the beef, which by the action of salt has been contracted, gives its salt to the brine in the bag, and so the process goes on, the beef expanding like a sponge, and gradually taking up a great part of the natural juice that it had previously lost in the salting process. In this way no loss of juice is sustained in steeping, and the brine in the bags, after being freshened by a night's dialysis in fresh water, can be used for soup.

By actual experiment, I find that a piece of beef (salted), weighing 1 lb. $10\frac{1}{4}$ oz., took up 9 oz. of juice, and that the absorption took place gradually as the strength of the brine became reduced. The brine used was 40° at first, and the process was continued till it stood 10° Twaddle.

This dialysed beef was then boiled with an equal weight of fresh meat, and 2 lbs. of it lost 1 oz. more weight in boiling than the fresh meat did.

Note on the Determination of Correct Time at the Observatory of the Glasgow University. By Professor Grant.

Read March 9, 1864.

Greenwich Mean Time being now regularly transmitted from the Observatory of the Glasgow University to the centre of the City of Glasgow, by a method of an unexceptionable character, it has occurred to me that it might not be uninteresting to the members of the Philosophical Society to be put in possession of some of the observations by

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which the time is determined, in order that they might be enabled thereby to form an opinion in regard to the degree of precision of the final results.

A list of such observations will be found in the accompanying paper. They refer to the interval which has elapsed since the transmission of Greenwich Time from the Observatory to Buchanan Street, down to the 7th of March. The number of star observations amounts to sixty-one, including eight observations of polar stars for the determination of the error in azimuth of the instrument.

The observations were made with the transit circle. The telescope of this instrument is furnished with an object-glass of six French inches in diameter. In the focus are placed seven vertical wires and one horizontal wire, besides a vertical wire, movable by a micrometer screw. The following are the equatorial intervals of the wires as determined by observations of Polaris in the year 1860:—

Wire.	Distance from the Mean of the Wires.
I.,	+ 41ˢ·30
II.,	+ 27 ·55
III.,	+ 13 ·81
IV.,	+ 0 ·08
V.,	— 13 ·82
VI.,	— 27 ·57
VII.,	— 41 ·36

These values appear from subsequent observations to have remained sensibly constant. The errors of adjustment of the instrument were determined by the same process which has been regularly employed at the Observatory since the beginning of May, 1860, and of which an account was given in a Report which I had the honour of addressing, on the 17th of April, 1861, to the Committee of the Senate appointed to visit the Observatory. I may state briefly that the error of inclination of the instrument is determined by means of a striding level. The error of collimation is ascertained by placing the telescope in a vertical position, with the object-glass downwards, and measuring the distance between the middle wire and its image reflected from a surface of mercury. The error of azimuth is computed from observations of Polaris, or some other star near the pole, combined with an equatorial star. Almost the whole of the observations were made by Mr. A. M'Gregor, the Junior Assistant at the Observatory, but the results are reduced to those of Mr. Dolman, the Senior Assistant, by taking into account the personal equation between the two observers, which amounts to—0ˢ·05. The following are the details of the observations:—

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SOUTH STARS.

Day, ...	**February 23.**			**February 23.**			**February 23.**		
STAR'S NAME, . .	β ARIETIS.			α ARIETIS.			ν AURIGÆ.		
	h.	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*
1st wire, ...			56·2			18·4			53·0
2d ,, ...			11·0			33·1			9·4
3d ,, ...			25·5			...			25·8
4th ,, ...			40·0			3·0			42·0
5th ,, ...			55·0			18·3			58·8
6th ,, ...			9·8			33·0			15·0
7th ,, ...	1	47	24·4	1	59	48·0	4	48	31·2
			281·9						295·2
Mean of Wires, . .	1	46	40·27	1	59	3·14	4	47	42·17
Collimation, +0ˢ ·103			+·11			+·11			+·11
Level, —0 ·003			·00			·00			·00
Azimuth, +0 ·415			+·26			+·25			+·19
Personal Equation,			—·05			—·05			—·05
Corrected Transit, .	1	46	40·59	1	59	3·45	4	47	42·42
Right Ascension, .	1	47	8·67	1	59	31·59	4	48	10·50
Error of Clock, . .			+28·08			+28·14			+28·08

Day, ...	**February 23.**			**February 23.**			**February 23.**		
STAR'S NAME, . .	δ ORIONIS.			ε ORIONIS.			ν ORIONIS.		
	h.	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*
1st wire, ...			55·6			...			39·4
2d ,, ...			9·3			24·5			53·7
3d ,, ...			23·0			38·2			8·0
4th ,, ...			36·8			52·0			22·1
5th ,, ...			50·7			6·0			36·4
6th ,, ...			4·4			19·8			50·6
7th ,, ...	5	25	18·1	5	29	33·8	6	0	4·9
			257·9						155·1
Mean of Wires, . .	5	24	36·84	5	28	52·16	5	59	22·16
Collimation, +0ˢ ·103			+·10			+·10			+·10
Level, —0 ·003			·00			·00			·00
Azimuth, +0 ·415			+·34			+·35			+·28
Personal Equation,			—·05			—·05			—·05
Corrected Transit, .	5	24	37·23	5	28	52·56	5	59	22·49
Right Ascension, .	5	25	5·35	5	29	20·56	5	59	50·52
Error of Clock, . .			+28·12			+28·00			+28·03

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SOUTH STARS—*continued.*

Day, ...	February 23.	February 23.	February 23.
STAR'S NAME, . .	γ GEMINORUM.	δ GEMINORUM.	PROCYON.
	h. m. s.	h. m. s.	h. m. s.
1st wire, ...	42·2	49·7	...
2d ,, ...	56·3	4·2	17·1
3d ,, ...	10·7	19·0	31·0
4th ,, ...	25·0	34·0	44·7
5th ,, ...	39·3	49·0	58·7
6th ,, ...	53·8	4·0	12·7
7th ,, ...	6 30 8·0	7 12 18·8	7 32 26·4
	175·3	238·7	
Mean of Wires, . .	6 29 25·04	7 11 34·10	7 31 44·85
Collimation, +0^s·103	+·11	+·11	+·10
Level, —0 ·003	·00	·00	·00
Azimuth, +0 ·415	+·27	+·25	+·32
Personal Equation,	—·05	—·05	—·05
Corrected Transit, .	6 29 25·37	7 11 34·41	7 31 45·22
Right Ascension, .	6 29 53·58	7 12 2·46	7 32 13·31
Error of Clock, . .	+28·21	+28·05	+28·09

Day, ...	February 23.	February 24.	February 24.
STAR'S NAME, . .	REGULUS.	α ARIETIS.	β TAURI.
	h. m. s.	h. m. s.	h. m. s.
1st wire, ...	59·4	18·7	28·9
2d ,, ...	13·7	33·7	44·5
3d ,, ...	27·8	48·4	0·0
4th ,, ...	42·0	3·2	15·7
5th ,, ...	56·1	18·2	31·3
6th ,, ...	10·1	33·2	47·0
7th ,, ...	10 1 24·3	1 59 48·1	5 18 2·8
	293·4	23·5	110·2
Mean of Wires, . .	10 0 41·91	1 59 3·36	5 17 15·74
Collimation, +0^s·103	+·10	+0^s·103 +·11	+·12
Level, —0 ·003	·00	—0 ·020 —·03	—·02
Azimuth, +0 ·415	+·29	+0 ·474 +·28	+·25
Personal Equation,	—·05	—·05	—·05
Corrected Transit, .	10 0 42·25	1 59 3·67	5 17 16·04
Right Ascension, .	10 1 10·22	1 59 31·59	5 17 43·95
Error of Clock, . .	+27·97	+27·92	+27·91

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SOUTH STARS—*continued.*

Day, ...	February 24.	February 24.	February 24.
STAR'S NAME, . .	δ ORIONIS.	ε ORIONIS.	ν ORIONIS.
	h. m. s.	h. m. s.	h. m. s.
1st wire, ...	55·8	...	39·4
2d ,, ...	9·2	24·7	53·7
3d ,, ...	23·0	38·3	8·0
4th ,, ...	36·9	52·0	22·2
5th ,, ...	50·8	6·0	36·4
6th ,, ...	4·4	19·7	50·7
7th ,, ...	5 25 18·2	5 29 33·6	6 0 5·0
	258·3		155·40
Mean of Wires, . .	5 24 36·90	5 28 52·16	5 59 22·20
Collimation, +0s ·103	+·11	+·11	+·11
Level, —0 ·020	—·01	—·01	—·02
Azimuth, +0 ·474	+·39	+·40	+·32
Personal Equation,	—·05	—·05	—·05
Corrected Transit, .	5 24 37·34	5 28 52·62	5 59 22·56
Right Ascension, .	5 25 5·34	5 29 20·55	5 59 50·56
Error of Clock, . .	+28·00	+27·93	+28·00

Day, ...	February 24.	February 24.	February 25.
STAR'S NAME, . .	PROCYON.	REGULUS.	δ ORIONIS.
	h. m. s.	h. m. s.	h. m. s.
1st wire, ...	3·4	59·8	55·4
2d ,, ...	17·2	13·9	9·2
3d ,, ...	31·0	27·9	23·0
4th ,, ...	44·9	42·0	37·0
5th ,, ...	58·9	56·1	50·7
6th ,, ...	12·7	10·2	4·5
7th ,, ...	7 32 26·7	10 1 24·3	5 25 18·3
	314·8	294·2	258·1
Mean of Wires, . .	7 31 44·97	10 0 42·03	5 24 36·87
Collimation, +0s ·103	+·11	+·11	+0s ·065 +·10
Level, —0 ·020	—·01	—·02	—0 ·039 —·02
Azimuth, +0 ·474	+·37	+·33	+0 ·387 +·32
Personal Equation,	—·05	—·05	·00
Corrected Transit, .	7 31 45·39	10 0 42·40	5 24 37·27
Right Ascension, .	7 32 13·30	10 1 10·23	5 25 5·32
Error of Clock, . .	+27·91	+27·83	+28·05

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SOUTH STARS—*continued.*

Day, ...	**February 25.**	**February 25.**	**February 25.**
STAR'S NAME, . .	ε ORIONIS.	PROCYON.	η CANCRI.
	h. m. s.	h. m. s.	h. m. s.
1st wire, ...	11·0	3·6	40·5
2d ,, ...	24·9	17·5	55·3
3d ,, ...	38·4	31·2	10·1
4th ,, ...	52·2	45·0	24·9
5th ,, ...	6·1	58·8	39·8
6th ,, ...	19·9	12·7	54·5
7th ,, ...	5 29 33·4	7 32 26·6	8 25 9·3
	365·9	315·4	174·4
Mean of Wires, . .	5 28 52·27	7 31 45·06	8 24 24·91
Collimation, +0·103	+·10	+·10	+·11
Level, —0·039	—·02	—·02	—·02
Azimuth, +0·387	+·32	+·30	+·24
Personal Equation,	·00	—·05	·00
Corrected Transit, .	5 28 52·67	7 31 45·39	8 24 25·24
Right Ascension, .	5 29 20·53	7 32 13·29	8 24 53·03
Error of Clock, . .	+27·86	+27·90	+27·79

Day, ...	**February 25.**	**February 25.**	**February 25.**
STAR'S NAME, . .	83 CANCRI.	ε LEONIS.	π LEONIS.
	h. m. s.	h. m. s.	h. m. s.
1st wire, ...	14·1	57·0	54·2
2d ,, ...	28·8	12·2	8·0
3d ,, ...	43·2	27·4	22·1
4th ,, ...	57·4	42·4	36·0
5th ,, ...	12·0	57·5	50·0
6th ,, ...	26·7	12·7	4·1
7th ,, ...	9 11 41·4	9 38 27·8	9 53 18·0
	403·6	297·0	252·4
Mean of Wires, . .	9 10 57·66	9 37 42·43	9 52 36·06
Collimation, +0·103	+·11	+·11	+·10
Level, —0·039	—·03	—·04	—·04
Azimuth, +0·387	+·25	+·22	+·29
Personal Equation,	—·05	—·05	—·05
Corrected Transit, .	9 10 57·94	9 37 42·67	9 52 36·36
Right Ascension, .	9 11 25·87	9 38 10·35	9 53 4·07
Error of Clock, . .	+27·93	+27·68	+27·71

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SOUTH STARS—*continued.*

Day, ...	**February 25.**	**February 25.**	**February 25.**
STAR'S NAME, . .	REGULUS.	ρ LEONIS.	*l* LEONIS.
	h. m. s.	h. m. s.	h. m. s.
1st wire, ...	59·9	31·6	58·9
2d ,, ...	13·9	45·4	12·9
3d ,, ...	28·0	59·2	26·9
4th ,, ...	42·0	13·3	40·8
5th ,, ...	56·2	27·4	54·9
6th ,, ...	10·4	41·3	8·9
7th ,, ...	10 1 24·7	10 25 55·3	10 42 23·0
	295·1	93·4	286·3
Mean of Wires, . .	10 0 42·16	10 25 13·34	10 41 40·90
Collimation, +0s·103	+·10	+·11	+·11
Level, —0 ·039	—·03	—·03	—·03
Azimuth, +0 ·387	+·27	+·28	+·28
Personal Equation,	—·05	—·05	—·00
Corrected Transit, .	10 0 42·45	10 25 13·65	10 41 41·26
Right Ascension, .	10 1 10·23	10 25 41·55	10 42 8·99
Error of Clock, . .	+27·78	+27·90	+27·73

Day, ...	**February 26.**	**February 26.**	**February 26.**
STAR'S NAME, . .	δ ORIONIS.	ε ORIONIS.	α ORIONIS.
	h. m. s.	h. m. s.	h. m. s.
1st wire, ...	55·7	...	40·8
2d ,, ...	9·5	...	54·7
3d ,, ...	23·3	38·7	8·7
4th ,, ...	37·0	52·2	22·4
5th ,, ...	51·0	6·2	36·4
6th ,, ...	4·7	19·9	50·0
7th ,, ...	5 25 18·7	5 29 33·6	5 48 4·7
	259·9		157·7
Mean of Wires, . .	5 24 37·13	5 28 52·34	5 47 22·53
Collimation, +0s·103	+·10	+·10	+·10
Level, —0 ·013	—·01	—·01	—·01
Azimuth, +0 ·148	+·12	+·12	+·11
Personal Equation,	—·05	—·05	—·05
Corrected Transit, .	5 24 37·29	5 28 52·50	5 47 22·68
Right Ascension, .	5 25 5·30	5 29 20·52	5 47 50·48
Error of Clock, . .	+28·01	+28·02	+27·80

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SOUTH STARS—*continued.*

Day, ...	**February 26.**	**February 26.**	**February 26.**
STAR'S NAME, . .	γ GEMINORUM.	η CANCRI.	ϵ HYDRÆ.
	h. m. s.	h. m. s.	h. m. s.
1st wire, ...	...	41·0	27·0
2d ,, ...	...	55·7	41·0
3d ,, ...	11·0	10·4	54·9
4th ,, ...	25·4	25·0	8·9
5th ,, ...	39·9	40·0	22·7
6th ,, ...	54·2	54·8	36·4
7th ,, ...	6 30 8·7	8 25 9·5	8 39 50·4
		176·4	61·3
Mean of Wires, . .	6 29 25·48	8 24 25·20	8 39 8·76
Collimation, + 0s ·103	+·11	+·11	+·10
Level, —0 ·013	—·01	—·01	—·01
Azimuth, —0 ·148	+·10	+·09	+·11
Personal Equation,	—·05	—·05	—·05
Corrected Transit, .	6 29 25·63	8 24 25·34	8 39 8·91
Right Ascension, .	6 29 53·55	8 24 53·04	8 39 36·86
Error of Clock, . .	+27·92	+27·70	+27·95

Day, ...	**February 26.**	**February 26.**	**February 26.**
STAR'S NAME, . .	ϵ LEONIS.	π LEONIS.	REGULUS.
	h. m. s.	h. m. s.	h. m. s.
1st wire, ...	57·0	54·1	59·8
2d ,, ...	12·1	8·0	14·0
3d ,, ...	27·3	22·0	28·2
4th ,, ...	42·2	36·0	42·4
5th ,, ...	57·7	50·1	56·6
6th ,, ...	12·8	4·0	10·4
7th ,, ...	9 38 27·9	9 53 18·1	10 1 24·3
	297·0	252·3	296·1
Mean of Wires, . .	9 37 42·43	9 52 36·04	10 0 42·30
Collimation, +0s ·103	+·11	+·10	+·11
Level, —0 ·013	—·01	—·01	—·01
Azimuth, +0 ·148	+·08	+·11	+·10
Personal Equation,	—·05	—·05	—·05
Corrected Transit, .	9 37 42·56	9 52 36·19	10 0 42·45
Right Ascension, .	9 38 10·35	9 53 4·07	10 1 10·22
Error of Clock, . .	+27·79	+27·88	+27·77

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South Stars—*continued.*

Day, ...	February 26.			March 3.			March 3.		
Star's Name, . .	γ Leonis.			α Arietis.			β Tauri.		
	h.	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*
1st wire, ...			19·0			18·6			28·8
2d ,, ...			33·5			33·4			44·2
3d ,, ...			48·1			48·2			59·9
4th ,, ...			2·8			3·1			15·6
5th ,, ...			17·6			18·2			31·2
6th ,, ...			32·3			33·2			47·0
7th ,, ...	10	12	47·0	1	59	48·0	5	18	2·8
			20·3			22·7			109·5
Mean of Wires, . .	10	12	2·90	1	59	3·24	5	17	15·64
Collimation, +0ˢ ·103			+ ·10	+0ˢ ·103		+ ·12			+ ·12
Level, —0 ·013			—·01	+0 ·068		+ ·06			+ ·07
Azimuth, +0 ·148			+ ·09	+0 ·296		+ ·17			+ ·15
Personal Equation,			—·05			—·05			—·05
Corrected Transit, .	10	12	3·03	1	59	3·54	5	17	15·93
Right Ascension, .	10	12	30·93	1	59	31·47	5	17	43·80
Error of Clock, . .			+27·90			+27·93			+27·87

Day, ...	March 3.			March 3.			March 4.		
Star's Name, . .	δ Orionis.			ε Orionis.			μ Geminorum.		
	h.	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*
1st wire, ...			55·8			10·9			33·5
2d ,, ...			9·7			24·8			48·2
3d ,, ...			23·2			38·2			3·2
4th ,, ...			36·8			52·1			18·0
5th ,, ...			50·9			5·9			33·0
6th ,, ...			4·5			19·9			48·0
7th ,, ...	5	25	18·2	5	29	33·4	6	15	3·1
			259·1			365·2			127·0
Mean of Wires, . .	5	24	37·01	5	28	52·17	6	14	18·14
Collimation, +0ˢ ·103			+ ·11			+ ·11	+0ˢ ·103		+ ·11
Level, +0 ·068			+ ·04			+ ·04	+0 ·053		+ ·05
Azimuth, +0 ·296			+ ·24			+ ·25	+0 ·355		+ ·21
Personal Equation,			—·05			—·05			—·05
Corrected Transit, .	5	24	37·35	5	28	52·52	6	14	18·46
Right Ascension, .	5	25	5·24	5	29	20·41	6	14	46·13
Error of Clock, . .			+27·89			+27·89			+27·67

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SOUTH STARS—*continued.*

Day, ...	**March 4.**	**March 7.**	**March 7.**
STAR'S NAME, . .	γ GEMINORUM.	α ORIONIS.	γ GEMINORUM.
	h. m. s.	h. m. s.	h. m. s.
1st wire, ...	42·4	41·4	42·8
2d ,, ...	56·8	55·0	57·0
3d ,, ...	11·0	8·9	...
4th ,, ...	25·4	22·8	25·7
5th ,, ...	39·7	36·8	40·3
6th ,, ...	54·2	50·6	54·7
7th ,, ...	6 30 8·6	5 48 4·5	6 30 9·0
	178·1	159·7	
Mean of Wires, . .	6 29 25·44	5 47 22·81	6 29 25·85
Collimation, +0s ·103	+ ·11	+0s ·103 + ·10	+ ·12
Level, +0 ·053	+ ·04	—0 ·043 + ·04	+ ·05
Azimuth, +0 ·355	+ ·23	+0 ·413 + ·31	+ ·27
Personal Equation,	—·05	—·05	—·05
Corrected Transit, .	6 29 25·77	5 47 23·21	6 29 26·24
Right Ascension, .	6 29 53·43	5 47 50·31	6 29 53·38
Error of Clock, . .	+27·66	+27·10	+27·14

Day, ...	**March 7.**	**March 7.**	**March 7.**
STAR'S NAME, . .	δ GEMINORUM.	η CANCRI.	ϵ LEONIS.
	h. m. s.	h. m. s.	h. m. s.
1st wire, ...	50·2	41·2	57·4
2d ,, ...	5·0	56·0	12·7
3d ,, ...	19·9	10·9	27·8
4th ,, ...	34·7	25·4	42·8
5th ,, ...	49·8	40·2	58·0
6th ,, ...	4·8	...	13·0
7th ,, ...	7 12 19·6	8 25 ...	9 38 28·3
	244·0		300·0
Mean of Wires, . .	7 11 34·86	8 25 25·50	9 37 42·86
Collimation, +0s ·103	+ ·12	+ ·12	+ ·12
Level, —0 ·043	+ ·05	+ ·05	+ ·05
Azimuth, +0 ·413	+ ·25	+ ·25	+ ·24
Personal Equation,	—·05	—·05	—·05
Corrected Transit, .	7 11 35·23	8 25 25·87	9 37 43·22
Right Ascension, .	7 12 2·28	8 25 52·94	9 38 10·33
Error of Clock, .	+27·05	+27·07	+27·11

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South Stars—*continued.*

Day,	March 7.			March 7.			March 7.		
Star's Name,	π Leonis.			Regulus.			ρ Leonis.		
	h.	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*
1st wire,			54·7			0·5			32·1
2d ,,			8·7			14·4			46·0
3d ,,			22·7			28·5			0·0
4th ,,			36·7			42·6			14·1
5th ,,			50·6			56·8			28·0
6th ,,			4·4			10·9			42·1
7th ,,	9	53	18·4	10	1	24·9	10	25	56·1
			256·2			298·6			98·4
Mean of Wires,	9	52	36·60	10	0	42·66	10	25	14·06
Collimation, +0^s·103			+·11			+·11			+·11
Level, —0 ·043			+·04			+·04			+·04
Azimuth, +0 ·413			+·31			+·29			+·30
Personal Equation,			—·05			—·05			—·05
Corrected Transit,	9	52	37·01	10	0	43·05	10	25	14·46
Right Ascension,	9	53	4·07	10	1	10·24	10	25	41·58
Error of Clock,			+27·06			+27·19			+27·12

Day,	March 7.			March 7.			
Star's Name,	*l* Leonis.			χ Leonis.			
	h.	*m.*	*s.*	*h.*	*m.*	*s.*	
1st wire,			59·1			53·7	
2d ,,			13·6			7·1	
3d ,,			27·7			21·2	
4th ,,			41·4			35·0	
5th ,,			55·7			49·0	
6th ,,			9·9			3·0	
7th ,,	10	42	23·9	10	58	16·9	
			291·3			245·4	
Mean of Wires,	10	41	41·61	10	57	35·06	
Collimation, +0^s·103			+·11			+·10	
Level, — 0 ·043			+·04			+·04	
Azimuth, + 0 ·413			+·30			+·31	
Personal Equation,			—·05			—·05	
Corrected Transit,	10	41	42·01	10	57	35·46	
Right Ascension,	10	42	9·03	10	58	2·68	
Error of Clock,			+27·02			+27·22	

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NORTH POLAR STARS.

Day, ...	February 23.	February 24.	February 24.
STAR'S NAME, . .	POLARIS.	POLARIS.	δ URSÆ MIN. S.P.
	h. m. s.	h. m. s.	h. m. s.
1st wire, ...	0 40 37	......	......
2d ,, ...	0 50 0	0 50 0	......
3d ,, ...	0 59 21	0 59 20	......
4th ,, ...	1 8 39	......	6 15 24·0
5th ,, ...	1 18 1	1 18 1	6 19 14·5
6th ,, ...	1 27 22	1 27 21	6 23 7·0
7th ,, ...	1 36 44	......	6 26 59·5
Mean of Wires, . .	1 8 40·57	1 8 40·22	6 15 21·96

Day, ...	February 25.	February 25.	February 26.
STAR'S NAME, . .	δ URSÆ MIN. S.P.	λ URSÆ MIN. S.P.	δ URSÆ MIN. S.P.
	h. m. s.	h. m. s.	h. m. s.
1st wire, ...	6 3 47·0	......	6 3 49·0
2d ,, ...	6 7 39·0	......	6 7 42·0
3d ,, ...	6 11 31·5	......	6 11 34·0
4th ,, ...	6 15 25·0	7 58 26	......
5th ,, ...	6 19 16·0	8 10 24	6 19 19·5
6th ,, ...	......	8 22 19	6 23 11·5
7th ,, ...	......	8 34 26	......
Mean of Wires, . .	6 15 24·20	7 58 21·98	6 15 26·94

Day, ...	March 3.	March 7.	
STAR'S NAME, . .	POLARIS.	δ URSÆ MIN. S.P.	
	h. m. s.	h. m. s.	
1st wire, ...	0 40 30	6 3 51·0	
2d ,, ...	0 49 51	6 7 45·0	
3d ,, ...	0 59 10	6 11 36·5	
4th ,, ...	1 8 29	......	
5th ,, ...	......	6 19 22·0	
6th ,, ...	1 27 13	......	
7th ,, ...	1 36 34	6 27 5·5	
Mean of Wires, . .	1 8 31·45	6 15 29·29	

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DAILY RESULTS.

Day.	Star's Name.	Sidereal Time.	Clock Slow.
		h. m.	s.
February 23, . .	β Arietis, ...	1 47	+ 28·08
,, . .	α Arietis, ...	1 59	28·14
,, . .	ι Aurigæ, ...	4 48	28·08
,, . .	δ Orionis, ...	5 25	28·12
,, . .	ε Orionis, ...	5 29	28·00
,, . .	ν Orionis, ...	6 0	28·03
,, . .	γ Geminorum, . .	6 30	28·21
,, . .	δ Geminorum, . .	7 12	28·05
,, . .	Procyon, ...	7 32	28·09
,, . .	Regulus, ...	10 1	27·97
		5 39	28·08
	February 23, at 5 h. sidereal, =28·08		
February 24, . .	α Arietis, ...	1 59	+ 27·92
,, . .	β Tauri, ...	5 17	27·91
,, . .	δ Orionis, ...	5 25	28·00
,, . .	ε Orionis, ...	5 29	27·93
,, . .	ν Orionis, ...	6 0	28·00
,, . .	Procyon, ...	7 32	27·91
,, . .	Regulus, ...	10 1	27·83
		5 57	27·93
	February 24, at 0 h. sidereal, =27·97		
February 25, . .	δ Orionis, ...	5 25	+ 28·05
,, . .	ε Orionis, ...	5 29	27·86
,, . .	Procyon, ...	7 32	27·90
,, . .	η Cancri, ...	8 25	27·79
,, . .	83 Cancri, ...	9 11	27·93
,, . .	ε Leonis, ...	9 38	27·68
,, . .	π Leonis, ...	9 53	27·71
,, . .	Regulus, ...	10 1	27·78
,, . .	ρ Leonis, ...	10 25	27·90
,, . .	l Leonis, ...	10 42	27·73
		8 40	27·83
	February 25, at 0 h. sidereal, =27·86		
February 26, . .	δ Orionis, ...	5 25	+ 28·01
,, . .	ε Orionis, ...	5 29	28·02
,, . .	α Orionis, ...	5 48	27·80
,, . .	γ Geminorum, . .	6 29	27·92
,, . .	η Cancri, ...	8 25	27·70
,, . .	ε Hydræ, ...	8 39	27·95
,, . .	ε Leonis, ...	9 38	27·79
,, . .	π Leonis, ...	9 53	27·88
,, . .	Regulus, ...	10 1	27·77
,, . .	γ Leonis, ...	10 12	27·90
		7 55	27·87
	February 26, at 0 h. sidereal, =27·86		

DAILY RESULTS—*continued.*

Day.	Star's Name.	Sidereal Time.	Clock Slow.
March 3, . . .	α Arietis, ...	1 59	+ 27·93
,, . . .	β Tauri, ...	5 17	27·87
,, . . .	δ Orionis, ...	5 25	27·89
,, . . .	ϵ Orionis, ...	5 29	27·89
		4 22	27·90
		March 3, at 0 h. sidereal,	=27·89
March 4, . . .	μ Geminorum, . . .	6 14	+ 27·67
,, . . .	γ Geminorum, . . .	6 30	27·66
		6 22	27·67
		March 4, at 0 h. sidereal,	=27·73
March 7, . . .	α Orionis, ...	5 48	+ 27·10
,, . . .	γ Geminorum, . . .	6 30	27·14
,, . . .	δ Geminorum, . . .	7 12	27·05
,, . . .	η Cancri, ...	8 24	27·07
,, . . .	ϵ Leonis, ...	9 38	27·11
,, . . .	π Leonis, ...	9 53	27·06
,, . . .	Regulus, ...	10 1	27·19
,, . . .	ρ Leonis, ...	10 25	27·12
,, . . .	l Leonis, ...	10 42	27·02
,, . . .	χ Leonis, ...	10 58	27·22
		8 44	27·11
		March 7, at 0 h. sidereal,	=27·17

SUMMARY.

		Clock Slow.
February 23, at 5^h	Sidereal Time, ...	$+28^s$ ·08
,, 24, ,, 0	,, ...	27 ·97
,, 25, ,, 0	,, ...	27 ·86
,, 26, ,, 0	,, ...	27 ·86
March 3, ,, 0	,, ...	27 ·89
,, 4, ,, 0	,, ...	27 ·73
,, 7, ,, 0	,, ...	27 ·17

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Remarks on the Great Lakes Titicaha and Aullaga, in Upper Peru and Bolivia, with Observations on their Drainage. By MATHIE HAMILTON, M.D., formerly Medical Officer to the London, Potosi, and Peruvian Mining Company, &c.

Read March 23, 1864.

THE great Lake Titicaha—*i. e.*, father of waters—in the province of Puno, Upper Peru, is more than 150 English miles in length, and in most parts it is about 70 miles in breadth between east and west. It contains several islands, and in some places it is very deep; for it has been sounded to a depth of several hundred fathoms, and in other localities no bottom was found at a greater depth.

The surface of the water in the lake is about 13,000 feet, English measure, above the level of the Pacific Ocean. In Upper Southern Peru and Bolivia, during the months of December, January, February, and March—which is the rainy season there—an enormous quantity of rain-water falls, and is conveyed into Lake Titicaha, and also into the Lake Aullaga. The Lake Titicaha has only one outlet, which is at its southern extremity, and known as the river Disaguadera, or drain: it runs towards the south, through a course of about 200 miles, and then enters the Lake Aullaga, which extends about 60 miles from north to south, and exhibits an average breadth of about 15 miles; but towards its southern end it is 20 miles broad from east to west. Though the quantity of water which flows into Lake Aullaga from that of Titicaha, through the medium of the Disaguadera, is very great, what ultimately becomes of that portion of the water which runs out from the western margin of Lake Aullaga is still a problem which remains to be solved. Some persons who never crossed the southern parts of the Desert of Carangas have attempted to explain the problem by asserting that the quantity of water conveyed by the river Disaguadera is not great, and that evaporation may dispose of the drainage of the great Lake Titicaha. I will attempt to give a very different solution of this rather curious question.

While I was residing on the west coast of Peru, Mr. Achavel, a very energetic and influential gentleman, known across the continent from Buenos Ayres to Lima, was at Arica; and having purchased a great quantity of goods from English houses in Tacna, he invited me to go with him to the interior of the continent, and visit the cities of Oruro, Potosi, and La Plata (Chuquisaca), and other extraordinary localities in that

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extraordinary portion of the globe. I gladly embraced the opportunity thus presented, and went with Mr. Achavel, crossing both the western and eastern great internal Andes of Southern Peru and Bolivia. Having crossed the western cordillera of the Andes, which there is 60 or 70 miles in breadth, we then descended to the great valley of Bolivia by the path which was cut in the side of the mountain. The depth of the valley from the summit of the path is about 2,000 feet perpendicular. The way down slants along the face of the mountain, and is very steep, with the abyss on one hand and the wall on the other. I noticed at the top of the cutting, which is about 14,000 feet above the ocean level, that there the face of the declivity presents a wall of diluvium of earth and water-worn rolled stones or pebbles, somewhat like the Pudding-stone Rock which is seen near the Foreland Point, in the Island of Cumbrae, in Frith of Clyde, near Millport. Geologists may explain how such a diluvial phenomenon was formed 14,000 feet above the present ocean. All our party were in advance, and on the descent, I being behind and alone, when suddenly a scene burst into view which was indescribably grand. It was the great valley of Upper Peru or Bolivia, bounded by the eastern or great internal cordillera of the Andes, more than 150 miles distant. I reined in my mule, and during some minutes contemplated that sublime spectacle. The atmosphere was very clear, and the spot where I then stood is at least 14,000 feet above the ocean level; yet the Eastern Andes, including the peaks of Sorato and Illimani, as I beheld them—they being 10,000 feet higher than my position—presented a mass of snow or ice, rising like a wall several thousand feet, piercing through a region of white clouds, and appearing again above those clouds, coruscating under the rays of a tropical sun. On the tenth day after marching from Tacna, our party—consisting of eight men, twenty-four mules, and one horse—arrived at the river called the "Disaguadera," or drain, about 9 P.M., and crossed to the Oruro bank at "el Barco"—*i. e.*, the boat—by means of a floating bridge moved by ropes and a swivel. Mr. Achavel and I slept in the house of the curate, situated close to the ferry: so that next morning I saw and examined the drain, which at that season (September being the dry season) was about 60 feet in breadth, apparently deep, the water moving sluggishly along. We arrived in the city of Oruro, and after staying twelve days there proceeded along the crest of the Andes to the city of Potosi, which by our route (the post-road) is distant from Oruro about 210 miles. We were eight days on the march between those cities; and after being fourteen days in Potosi we went to the capital of Bolivia, which is 100 miles from Potosi, in an east by north direction.

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After fifteen days' residence in Chuquisaca we returned to Potosi; and at the end of other seven days we left it to return to the west coast by the Desert of Carangas, a route which during many years had been shut and prohibited by the government, to prevent the smuggling of silver from Potosi to the coast of the Pacific Ocean. At that period all the silver obtained from the mines of Potosi was by law delivered to the mint in Potosi, and was subject to a tax of from 20 to 25 per cent., according to circumstances. The mint buildings in Potosi are larger than the London one, and were erected at the cost of the King of Spain about the year 1750.

Prior to our going from Potosi to Chuquisaca, Achavel had arranged with the proper authority in Potosi to travel with silver by the route which we traversed, and which was known to very few of the residents then in Potosi. Our party consisted of eight men and thirty-eight mules, ten of which carried about a ton and a half of silver, or 3 cwt. each. A trustworthy and intelligent muleteer was engaged to guide us through the desert, and a servant to provide a few things needed for such a journey, such as a little wood, charcoal, bread, potatoes, &c.: but the person who acted as purveyor, though a native of Potosi, being ignorant of the route and time required for our journey, gave us so little bread that towards the latter part of the journey we were ten days without a crumb!

We started from Potosi on Saturday, 3d November, and descended through a chasm in the mountain to the depth of at least 1,500 feet, the rocks appearing as if they had been riven asunder by a terrible convulsion. We then turned south for some miles, went along a narrow defile with rocks on both sides, rising in most places perpendicularly to the height of many hundred feet above us. We soon began to climb a mountain; and before sunset I took a final view of the city of Potosi, we being south from it, and about 15,000 feet above the ocean level.

We were three days travelling among the mountains of the Cordillera, during which we suffered much from cold and fatigue; but on the 7th November descended into the valley of the Marquis, in which there is a stream called the river of the Marquis; but at that time it was shallow. We went along its bank to the south till a ridge of water-worn rocks was turned, after which we went in a north-western direction. When turning the ridge of the Marquis I distinctly saw the bifurcation of the great eastern and western cordilleras of the Andes, their tops covered with snow. The bifurcation is in nearly 21° south latitude. On the 8th we crossed a stream which the guide affirmed runs into the Lake Aullaga; but we concluded that it flowed from the lake. It

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being towards the end of the dry season, and a wide expanse of dry alluvial mud having to be passed by us about dusk, it was not easy to decide the direction of the small stream; but during the wet season it must be as broad as the Thames at Hampton Court. We now moved, not in a direct line, west to the western Andes, but traversed the hypothenuse, through the desert towards the mountain of Sahama, which is noted in a map issued by the Admiralty as being more than 22,000 feet in altitude above the ocean. We saw Lake Aullaga on our right, and an interminable wilderness before us, without water, or vegetation, or inhabitants, except one small Indian village of twenty or thirty huts. There was a curate with whom Achavel and I remained half an hour in the open air. He said that his parish was very extensive, and that in this village, Andamarca, the natives speak the Aymara language, they being totally ignorant of the Qquichua, that which is spoken in Potosi and in most parts of Bolivia and Peru. The curate stated that the distance between Potosi and Andamarca is 67 leagues (about 200 miles) by the nearest route, but that we had travelled by a longer way: he also said that from Andamarca to Arica, on the coast, is 84 leagues, or 250 miles. Behind the village, on a slope or ridge, I saw a row of the *Cactus Peruana*, some of them very large. The Indians here have little intercourse with others. They merely know that Potosi exists; but rarely has that city been seen by them, for both the distance and privations incident to the journey are great to them, who must travel on foot: also the difference of language is very great, as the Aymara is more euphonious than the Qquichua, which has more consonants; it sounding harsh to a musical ear, while the Aymara sounds more like Hebrew.

11th. This morning the guide warned us that during two days' march (about 70 miles), we would not find water; therefore each man filled his bottle with nasty water, from a hole where we had passed the night, five leagues from Andamarca.

12th. This morning Achavel rebuked the cook for giving us llama's flesh to supper, and also to breakfast, when a sheep could have been obtained. During the march through the desert the fuel used by our cook was the stunted prickly shrub found there, a furze whin bush, it being a species of the *Ulex Europæus* of Linnæus; also the dry droppings of the Alpaca tribe of animals, which burns like good turf. The only food for those creatures there is a tall wiry sort of grass called *ichu* (*jarava, in the flora Peruana*). We made long journeys these two days. Our guide seems to move through this wilderness by observing the sun by day, and other celestial objects when a march is continued after nightfall. In this day's march we crossed a stream

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which flowed slowly towards the south-west; the water was good, and the quantity many times greater than that which we crossed on the 8th. This is one of the drains of the Aullaga Lake, but none of us knew how it terminates.

13th. This morning the snow-covered mountains of the Western Andes were seen by us for the first time since our return from the interior, and was a welcome spectacle to us, as the journey is exhausting both mules and men. We have not had any bread these last two days, though we are still at least eight days' journey from the coast; also urine from the mules, when voided, is not unlike blood in colour.

A long march being necessary this day, we started early, and moved over a level pampa, studded with innumerable llamas and alpacas; but not a vestige of man was seen. Having travelled six hours, we arrived at a river which flowed towards the south-west, being nearly at right angles to our route, and distant about 30 miles from the one which we crossed yesterday. The water was clear, and passing over a bottom of sand and gravel at a velocity of 1½ or 2 miles an hour.

So far as within my observation, both the breadth and depth of the stream were rather uniform, and the quantity of water passing was, at least, four times greater than in that of yesterday. Neither the guide, nor any person I ever knew, could tell how this stream terminates; but I believe that this nameless river, which is the great drain of Lake Aullaga, and through it of Lake Titicaha, is that which during a long period has often been a subject of inquiry among intelligent residents on the coast of Southern Peru. The water here was fully twenty feet wide, and the depth such that my mule, though a long legged animal, had water to its knees when in mid-channel. The quantity conveyed here from Lake Aullaga must be very great during the rainy months in those regions; for this month (November) is near the close of the dry season, which commonly lasts eight months. Our party had all crossed the river, ascending a bank about 15 or 20 feet high, and were moving along at the usual pace of 3 miles an hour, while I was behind dismounted; and when about to take a soda powder, I having lifted water from the river, saw to my surprise two Indians standing close behind. It is likely that while our troop was passing they had been in the supine position, but now seeing only one man they ventured to come near. When I took the refreshing draught they were astonished, one of them saying in Spanish, It is boiling; for here was a double wonder, as to them it seemed that the white man made cold water boil by stirring it in a cup with his finger, and then drank it while boiling. It is probable that those simple beings were accused of having invented a story, and of telling a great lie; for Dr.

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Solander, the companion of Sir Joseph Banks while travelling in many lands, was insulted at a dinner party in London by Samuel Johnson for stating that he had seen a fowl boiled in a hot spring.

After passing the river we went some leagues, and remained for the night near a pool or hole containing bad water. All those holes in this wilderness had been dug in past times to retain surface water, which runs into them during the wet season.

Having travelled through the Desert of Carangas from the Eastern Andes, we, on the 14th of November, began to ascend the western cordillera, at some distance to the north of the Sahama mountain. During some hours previous to the storm bursting on us we saw a dense black cloud over the side of the mountain; but as during our journey across the desert we had not a drop of rain, nor hail, nor snow, we did not expect the coming tempest. About 3 o'clock P.M. we were enveloped in darkness, so that a general halt ensued without any order being given, for the mules, with their instinctive sagacity, stood still of their own accord. While the storm was at the worst, the thunder was not heard as in a succession of peals, but was continuous. The darkness was often made visible by the lightning, which appeared to run along among our feet, as if it had issued from the rocks, in place of descending from above. It assumed various forms, being at times forked and of different colours, and also like sheets of fire gliding along the earth's surface. No rain fell, but much hail, or rather pieces of ice, of a size and quantity so great as to give me more uneasiness about my mule than the thunderbolts; because the latter sets at naught all human efforts to evade its stroke, while the hail could in some degree be warded from the animal by means of those coverings which the traveller uses on such a journey. The storm lasted with us two hours, but in its greater intensity only half an hour; when the darkness began to give way, it was seen that no accident had happened to any of our party. After sunset, snow fell until midnight; all of us, both men and mules, sleeping on the snow, which was dry as peppercorns; and though we had been fourteen hours in the saddle we slept well, and got supper or breakfast next morning at an elevation of at least 15,000 feet above the ocean level. The pack-saddles were as usual removed from the mules, they standing huddled close together, with snow to quench thirst. In a map which was sent to me by Sir Woodbine Parish, F.R.S., &c., from the Hydrographer's Office, Admiralty, the Sahama Mountain is marked as being 22,350 feet in altitude above the ocean; and if so, we passed the nights of the 14th and 15th November at an elevation of not less than from 17,000 to 18,000 feet above the ocean level, which explains why our mules on the

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15th moved very slowly, their ball-and-socket joints not having sufficient atmospheric pressure. Those terrific discharges of electricity occur almost every day, during several months every year, over thousands of miles on the mountain ranges of South America; and we may conclude that Nature may accomplish some great work through the medium of electric phenomena, as displayed in some mining districts in various countries.

With reference to the drainage of the Lakes Titicaha and Aullaga, and the water that is discharged from the latter, the attempt to dispose of it by the evaporation theory is in my opinion inadmissible, for the following reasons:—The quantity of water which enters Lake Titicaha through the medium of numerous streams which run into it, and the rain-fall into it during the wet season there, is very great; while its only outlet is the Disaguadera or drain, which, after a course of about 200 miles, goes into Lake Aullaga, which from its western margin sends out three streams, two of which I crossed on the 12th and 13th November. As to the theory of evaporation explaining what becomes of the surplus water of those lakes, it cannot be received, because facts tangible to all persons who have seen them prove that evaporation is not so rapid and effective as some persons are disposed to conclude. All those pools or holes in the ground, which in past ages were dug for the reception of surface water during the rains there, contained more or less which had been in them since the close of the previous rains, nearly eight months before: the water was bad, but it was there. What is more convincing as to the evaporation theory not being sufficient to account for what becomes of the surplus waters of those lakes, is the fact, that the city of Potosi has, during nearly three centuries, been supplied with water by gravitation from a reservoir situated a short distance above the city, which has two sluices,—one for the city, which is conveyed by pipes; the other, for the grinding of silver ore, is sent through a ravine called the river.

M. Acarete, who was in Potosi in 1656, states that the city and works are supplied with water from a lake enclosed with walls, which is about a quarter of a league above the city; so that said artificial reservoir, on the principle of the Loch Katrine and Gorbals Water Company, &c., is about 14,000 feet above the ocean, to collect rain-water and melted snow. In 1735 the Kings of France and Spain sent a party of savans to South America to make observations and report. One of them—Ulloa, in his work, Madrid, 1792—states that the celebrated lake was formed at great cost among hills for gathering rain-water.—*Vide Noticras Americanas*, by Ulloa.

When I was in Potosi said reservoir had never been without water,

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and we may conclude that the surplus water of the great Lakes Titicaha and Aullaga are not disposed of by evaporation, but rather through the medium of a subterraneous passage under the Andes of the western cordillera towards the Pacific Ocean.

On the Prevention of Smoke, and the Means adopted by the Authorities of Glasgow for its Suppression. By Mr. William Gorman.

Read April 20, 1864.

Glasgow is singularly unfortunate in having a peculiar local Act of Parliament, designed, no doubt, to suppress the nuisance of smoke, but operating in practice so as to be entirely useless for that purpose. This Act was passed in 1827, and provides "that furnaces shall be constructed agreeably to the most approved plans then in use, or which may be in use at the time" of their construction; and as far as this Act refers to the *chimneys* of steam-boiler furnaces, the law is concise, and can be complied with; but there is no plan or dimension of furnace mentioned in the Act, nor any instructions given by the authorities as to what is the most approved plan. We learn this much, however, that the plan is to be in use at the time, and that it is to be the most approved plan,—we infer, most generally approved by furnace owners,— the construction and management of which furnaces are to be agreeable to such directions as may be given in a report by three engineers, or other persons of skill in such matters.

While the furnace owners of Glasgow have been paying large sums of money for smoke-preventing plans, have those plans been the *most approved?* or were they in use at the time the three engineers, or men of skill, gave in their report to the court? According to the Act, those men of skill, or engineers, had no right or power to report schemes of their own, or plans which were not *in use*, or not the *most approved.*

The plan of dividing the furnace mouth, alternate firing, and perforating the doors, adopted by our authorities, is ascribed to Mr. C. Wyse Williams, who obtained the premium at the competition at Newcastle-on-Tyne in 1858; but it is to be observed that the plan used by him on that occasion had shutters for varying the apertures in the doors at will, and had no division in the mouth of the furnace,—two most important distinctions from the plan adopted by our authorities. The shutters for closing the apertures giving complete control over the

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admission of air, and as the mouth of the furnace was not divided, it could be wrought to the greatest perfection the plan is capable of, and is the simplest and perhaps best plan known for preventing smoke (when the admission of air over the fuel alone is depended upon for that purpose), with the exception of the plan well known as the fireman's plan, which consists in leaving the furnace door a little open after firing, till the smoke is burned off. It is also to be remarked that the plan of Mr. Williams is departed from by our authorities very materially in a most essential point. He is most particular, in having large space over the fire and in the flame-bed or combustion chamber, to give the air and gases room and time for uniting and igniting, so that complete combustion may be effected. Our authorities follow a directly opposite course, in raising the fire bars as close to the bottom of the boiler as possible, and contracting the space behind the bridge so as to leave just sufficient room for the rapid passage of the hot gases.

Although the appearance of smoke may be lessened by highly heated contracted passages, it does not follow that the combustion of the fuel is more complete; and such arrangements must have a prejudicial effect on the boiler, by confining the heat at its greatest temperature to a small portion of its surface.

Nor is this all. It is well known that if smoke is highly heated amongst carbonic acid gas, it takes up a part of its oxygen, forming carbonic oxide, which is colourless, and which passes away unconsumed when the supply of air is limited. This is the effect produced by the furnace arrangements adopted by our authorities. The smoke disappears, but it is not consumed.

The Act of Parliament previously referred to provides that the smoke shall be consumed; and this is a wise provision. But the authorities seem to have found it impossible to prevail on furnace owners to allow so many holes in the door as would prevent smoke by Williams' plan; as he states, "that if there be not room in the furnace door to admit of as many half-inch or three-quarter-inch holes as will prevent smoke, then a plate is to be inserted in the wall of the bridge, with the requisite number of holes for air."

This is an honest admission of the difficulties which occur in practice; and as Williams disdained the plans for heating smoke to make it disappear, but held on by consuming the gases, his only course was to admit air, increasing the quantity till smoke disappeared.

In short, the plan of Williams, if wrought with permanent holes, as adopted by our authorities, could not be used with the coals of this locality; and it never was the *most approved* plan, and could not

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be enforced in accordance with the Act; consequently we have the contraction of the spaces usually allowed for combustion, and the appearance of smoke prevented, not by directly consuming the coal gas or smoke, so much as by heating it mixed with carbonic acid gas, thereby forming carbonic oxide, which, as before stated, escapes from the chimney unconsumed when the supply of air is limited.

As an evidence that such is the case, it may be mentioned that in the neighbourhood of Market Street a chimney was cured by the authorities: but the people who live in the vicinity find the cure to be worse than the disease; for although there is less smoke to appearance, yet the fumes from the chimney are much more sickening and oppressive to the breathing than the former smoke was.

Having shown that the plans adopted by our authorities for the prevention of smoke result in the production of a large amount of carbonic oxide, which is most inimical to health, it becomes a question, from a sanitary point of view, how far those smoke-disguising measures ought to be permitted. The Act provides that the smoke is to be consumed, not simply rendered colourless; and if it can be shown that carbonic oxide is far more subtile and dangerous to health than black smoke (as it easily can), then the authorities are violating the intention, as well as not conforming to the letter, of the Act, by using the plans they at present adopt to prevent smoke.

In the late inaugural address of the President of Engineers of Scotland, he stated that coals were burned most economically when producing the blackest smoke in an ordinary steam-boiler. It is very pleasing to find a deliberate statement, founded on disinterested data, expressed by high authority on this subject; as I have on several occasions, and in various papers, expressed an opinion to the same effect, and have had it amply borne out in practice, that with the usual means for preventing smoke, which includes the various modes of supplying air to the gases for combustion, no saving can be effected on the ordinary steam-boiler furnace. We often hear of great saving—so much as 30, or even 50 per cent., &c.—from burning the gas or smoke of coal; but there must be some other way of accounting for such results, as it will be found that, with the same coal, boiler, and furnace arrangements, as much, if not more, work may be done by the usual smoky method as by the usual smoke-preventing apparatus, even when wrought with the greatest care. I was told of a case where an engineer had reduced his consumpt of coal from 24 cwt. to 16 cwt. of coal per day, by preventing or burning the smoke; but it turned out, on inquiry, that he had got a larger boiler, and altered his furnace arrangements and management. Such statements as the above ought not to be made, as they are cal-

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culated to mislead, and throw discredit on properly conducted trials; and I would state that no economy ought to be set down to the account of smoke prevention which is not altogether due to burning the coal gas. In the experiments I have recorded, the furnace and boiler arrangements are identical in each case, and the saving is wholly due to burning the gas of the coal.

It is now five years since I published a paper on the combustion of coal, in which was pointed out that which seemed to me to have been overlooked in the different plans proposed for the combustion of the gas of coal, to the effect, that while the gas is being evolved from newly laid-on coal in an ordinary furnace, the coal gas is so largely mixed with carbonic acid gas, resulting from the combustion of the underlying hot cinders or coke of the former charge of coal, that it cannot be burned.

When a fresh charge of coals is thrown, in the usual manner, on a strong, brisk fire of coke, a large quantity of coal gas is evolved; and the practice hitherto has been simply to admit fresh air for its combustion. But this practice is erroneous; for while the coal gas is being evolved another gas is being formed from the combustion of the underlying coke (namely, carbonic acid gas), which, by rising and mixing with the coal gas, must effectually prevent its combustion,—for it is well known that combining equivalents of coal gas and air will not burn if they be mixed even with a seventh part of carbonic acid gas, whereas the carbonic acid gas present while a furnace is in active operation is fifty times greater than that amount, so that no amount of air supplied to such a mixture would render combustion possible.

A committee of eminent scientific gentlemen, appointed to inquire into the smoke question, found that a large opening made in the door or flue of a furnace for the admission of air prevented smoke, and that it did not matter much how or where the air was admitted, provided the requisite quantity was supplied. That finding is a true representation of the case. Opening a furnace door a few inches, or any other expedient answering the same end, acts like magic on the smoke—it disappears instantly. This fact was well known towards the end of last century, patented in different forms, and because it wasted coal rejected by the furnace owners; and every scheme having the least claim to attention, which has hitherto appeared, is simply a repetition of that operation in one form or another. Preventing smoke being an easy matter, an easy explanation seems to have been arrived at, viz.—that opening the furnace door merely supplied fresh air for the combustion of the coal gas; and it is owing to this explanation being erroneous, that the hundreds of schemes for utilizing the heat due to the coal gas have failed in effecting their object.

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Perforating or partially opening a furnace door, or letting in a large volume of air at the bridge, sides, or centre, or any other part of a furnace above or beyond the fuel, weakens the draught through the fuel on the grate, so much as to prevent the production of carbonic acid gas, the result being the formation of carbonic oxide, a gas which is combustible, and burns with the coal gas when air is present. In this way it is that the ordinary methods effect the combustion of the coal gas; but the volume of air required to weaken the draught through the grate bars is so large that it generally carries away more heat than what is obtained by the combustion of the coal gas.

The object of the Coal Economising Furnace is to produce the coal gas free from carbonic acid gas, and at the same time to effect its combustion without this large volume of air passing through the flues. This is accomplished by closing the ash-pit so much as to lessen the draught through the coke on the grate bars, to the extent necessary for preventing the formation of carbonic acid gas while the gas is being evolved from the newly thrown-on coal. Provision is at the same time made for supplying air under the most favourable conditions, for consuming the coal and carbonic oxide gases while they are emanating from the coke and coal. By these means complete combustion of both coke and coal gas can be obtained without permitting any more air to pass through the flues than what is required for combustion, the closing of the ash-pit rendering unnecessary the great volume of air required in the ordinary plans for lessening the draught.* The draught of a furnace cannot, therefore, be injured, but must be improved by the application of the Economiser; and the whole force of the draught is employed in projecting numerous jets of air into the furnace amongst the gases, on which they act with all the force and effect of a blow pipe.

To burn the coal gas so as to prevent smoke by the ordinary methods of perforated doors, plates, or valves let into the bridge-wall or flame-bed of a furnace, requires openings equal to 6 inches in area for the admission of cold

* The truth of these statements is fully established by the following considerations:— Mr. C. W. Williams says, that from 4 to 6 inches of opening for each foot of grate bar surface is necessary for consuming the coal gas; while another writer, advocating the same system, says that from 6 to 8 inches answers better. Mr. Prideaux allows 12 square inches per foot of grate, but the air is heated by his door, and that to some extent reduces the admission of air due to so large an area. Now, in a series of twenty-one trials made to test the value of the Coal Economiser, in which about 60 tons of coals were burned, the area for admitting air for consuming the coal and carbonic oxide gases was only 2½ square inches to each foot of grate, and the air was heated and shut off gradually, so that the effective area could not be more than an inch and a half, and that only while the gas was being evolved; and to prove the entire fallacy of the systems which require 6 inches of cold air to the foot of grate, it may be stated that all the products of combustion of the coals before mentioned passed through an area of 7 square inches to the square foot of grate, and that at the point where the gases were hottest,—that is, over the bridge,—the combustion reaching as high as 36½ lbs. per square foot of grate.

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air for each square foot of grate; the Coal Economiser can effect the same purpose more efficiently with openings equal to 2½ inches area; but the air is heated and shut off gradually, so that the effective area for cold air cannot exceed 1½ inch to the foot of grate; so that a constant stream of cold air 4½ inches in area for each foot of grate, which is not required for combustion, is admitted into the furnace by the ordinary means for preventing smoke. This unnecessary air will, in an ordinary furnace consuming about 3½ cwt. of coal per hour, amount to upwards of 2 tons in that time. This large volume of air reduces the temperature of the furnace, and consequently its power of convection. But the evil does not end here; the escaping products of the furnace are in like manner increased in volume; and as the same surface of boiler (or object to be heated) cannot take in so much heat when the temperature is lowered, the heat passes away in the escaping products. These escaping products being nearly doubled in temperature by the large admission of air into the furnace, it was adduced by the advocates of the usual system, as a proof of the greater heating power of the furnace, whereas the reverse is the true state of the case. Some idea may be formed of the great quantity of heat lost in this way, by comparing the loss with some tangible work. The products of ordinary steam-boiler furnaces generally escape at the temperature which would melt lead. Now the 2 tons of air before mentioned as passing through the furnace without doing work, carry away as much heat as would raise upwards of 15 tons of lead to the melting point. Even this is understated, as the temperature of escaping products is always raised when large quantities of air are admitted into a furnace.

The accompanying is a representation of the Coal Economising Apparatus, as applied to a cylindrical boiler with internal furnaces. It consists essentially of two valves, one being placed on the ash-pit and another on the door of the furnace. These valves work in concert, the one admitting air at the door to the coal gas for its combustion while it is being evolved, and the other at the ash-pit for the combustion of the coke. The whole of the apparatus is attached to the front and outside of the furnace, so that the boiler or setting is not interfered with in any respect whatever; nor does it interfere with the duties of the stoker, as the apparatus is altogether self-acting, the opening of the furnace doors setting the valves; and it is so simple in its construction that it is not liable to derangement.

The Coal Economising Furnace possesses all the essential conditions which have hitherto been devised for burning coals economically, with the addition of the peculiar feature already referred to, of producing the coal gas in the furnace free from carbonic acid, by which a considerable saving in fuel can be realized over and above any other furnaces in which coals are burned.

Since writing the papers referred to, I have been successful in applying the principle to nearly 200 furnaces, and have had ample opportunity of testing the principle; and I am very glad to say that coals can be burned so as to prevent smoke, and with large economy. A

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sheet is hung up in the hall, recording the results of twenty-one trials, from which it will be seen that much greater economy has been obtained from burning the gas of coal in an ordinary boiler than what has been obtained in any other authenticated trials under like circumstances. These trials were made in the usual course of working with dross of a low price. The boilers and coals were uncovered, and consequently exposed to all kinds of weather during the trials, which also include the loss from cleaning and kindling the fires.

It will be perceived that although these trials were made under every disadvantage, more work has been done with a given weight of fuel by preventing the coal gas from being mixed with carbonic acid gas, to the extent of 18 per cent. I have some trials going on with water metres in the meantime under more favourable circumstances, from which I expect greater economy, the results of which I will be glad to communicate to the Society at a future time.

Something might be done by this Society to bring about a means of testing plans, and also offering a premium for the best fireman; besides, were means provided, firemen could be trained up to the mark, so that coals could be burned without being wasted, and smoke prevented with great profit to furnace owners: and were the real state of the case more fully established by respectable disinterested and authenticated trials, that furnace owners could rely upon, then there would be no need for forcing them to consume the smoke of their furnaces, as a few pounds laid out in proper apparatus for consuming the gas, as well as the solid part of coal economically, would be found a very profitable investment. There are plenty of works where such arrangements could be carried out without incurring much expense; and I am convinced it would be a great boon to Glasgow, as, after all, the fireman must work properly before any advance can be made in saving coal; and before smoke will be effectually prevented the furnace owner must find a profit in doing so. I may mention that the furnaces during the above trials were every way the same, except changing the doors, and were fired most carefully by Robert Gates, one of the firemen at the works.

The following Table shows the average results of twenty-one trials made at the works of Messrs. Walter Crum & Co., Thornliebank, to compare furnaces wrought with the Economiser, and with the ordinary close doors, used alternately, day about.

The boiler is 26 feet long, with two internal flues fired inside; the furnaces are 3 feet wide by 5 feet long each, being 30 feet of grate.

The coals were Wishaw dross, each pair of trials being taken from the same truck, and carefully weighed.

The feed water was passed through three of Kennedy's metres, and the

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indications averaged;—the temperature of the water taken every 15 minutes, as also the steam pressure, and averaged. An account was also kept of the time of firing, poking, and cleaning, so that every particular could be compared.

AVERAGE RESULTS OF TWENTY-ONE TRIALS, FROM 30TH SEPTEMBER TILL 7TH DECEMBER, 1861.

		COMMON DOORS.	ECONOMISER.	Per Cent. more.	Per Cent. less.
Coals burned.	Area of fire grate,......	30 sqr. feet.	30 sqr. feet.	...	...
	During each trial,......	55·13 cwt.	50·55 cwt.	...	9·0
	Total per hour,..........	8·41 cwt.	7·169 cwt.	...	17·3
	Per foot of grate per hour,.................	31·4 lbs.	26·76 lbs.	...	17·3
Water evapd. from 60°	During each trial,......	3,381 galls.	3,648 galls.	7·8	...
	Total per hour, ...	515 galls.	520 galls.	·9	...
	Per ton of Coals,........	1,228 galls.	1,451 galls.	18·16	...
	Per pound of Coals, ...	5·481 lbs.	6·478 lbs.	18·16	...

The Economiser has thus evaporated more water in a given time, and upwards of 18 per cent. more from the same weight of coal.

In the above trials the furnaces were worked to their extreme power throughout. In one trial there were burned nearly 10 cwt. of coal in the hour with close doors; and in the trial with the Economiser, 591 gallons of water were evaporated with 8·11 cwt. per hour, the grates being each 3 feet wide by 5 feet long—in all 30 square feet.

The writer has always found close doors to yield a greater economy, and do more work in a given time, than perforated doors, the same furnace and grates being used in each case. It may be mentioned that in the above experiments 55 tons of coal were burned, and upwards of 80,000 gallons of water evaporated.

The feed water being reduced to 60° temperature in the above table, one-sixth requires to be added to show the economic value of the fuel or water evaporated from 212°.

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On a Section of Glacial Clay at Errol, Perthshire.

By Rev. Henry W. Crosskey.

Read April 20, 1864.

The section to which I wish particularly to draw the attention of the Society, as remarkably illustrative of a relationship between the glacial beds of the east and west of Scotland, occurs at Errol, in the brickfield not far from the station of that name, upon the Perth and Dundee Railway.

In the pits at Errol a complete section was fairly exposed during the excavations of the winter season, exhibiting the exact succession of strata familiar to the student of the Paisley and Bute clays, and revealing the existence of the same physical order in the glacial beds upon the east as that which is persistent through the whole basin of the Clyde, and which has hitherto been described and discussed as a merely local phenomenon. These excavations being now covered, to a large extent, with water, it becomes important to put on record a note of this fact.

1. The base of the series is the true boulder clay. It is very hard and difficult to break up, even with the pickaxe, and full of striated blocks and stones. Exactly also, as upon the west, its undulations are very rapid; and its surface is uneven to such an extent that the superimposed beds vary greatly in their depths over limited areas.

2. Upon the true boulder clay rests a highly laminated clay, entirely destitute of fossils. The occurrence of this highly laminated unfossiliferous clay intervening between the true boulder clay and the arctic shell bed is one of the most curious phenomena of the Clyde district; and no satisfactory explanation of its existence has yet been offered. Its detection at Errol gives it a considerable extension in space, and exhibits it, not simply as a local peculiarity, but as a general fact connected with the development of the whole formation.

3. Upon this unfossiliferous laminated clay rests the shell bed, which is on an average only about 1 foot thick. Through the west a corresponding bed of shells, from 1 foot to 2 feet thick, extends with great persistency along many miles of the glacial beds.

The fauna at Errol appears to correspond in a considerable degree with that described by the Rev. T. Brown, F.R.S.E., at Elie, in the basin of the Forth.

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At Errol, as at Elie, species occur not yet detected in the western clays, viz.:—

Pecten Greenlandicus—exquisitely preserved.

Leda.—No doubt the species described by Dr. Torrell as "a new yoldia found at Spitzbergen, in 80° north latitude."

Leda.—(?) Probably "Leda Portlandica" of the Montreal beds.

Crenella nigra.—Only one valve of this shell has been found in the Clyde district, but here it is abundant, although it rapidly decays on exposure to the air.

A species of seal.

Among examples common to the Clyde beds are:—

Saxicava rugosa.—Large arctic variety.

Tellina proxima.

Natica.—(?) Probably "Greenlandica," but imperfectly preserved.

Buccinum undatum.

Balanus Porcatus.—(Uddevallensis of Smith.)

There are other species in the collection now exhibited to the Society; but the difficulty of identifying them is so great that the publication of a complete list must, in the meantime, be deferred. Several varieties of foraminifera also occur in the clay, of which it is hoped to present an account on some future occasion. The general arctic character of the group is sufficiently determined by the specimens now shown, although much remains to be done in its more minute development.

Striated stones occur in the shell bed in the same way as they are sometimes found among the shells at Paisley.

4. The shell bed is succeeded by a clay as completely unfossiliferous as the laminated clay beneath it.

The line of junction between the laminated clay and the shell clay is very sharp and decisive; but between the shell clay and the overlying unfossiliferous clay it is not so finely determined in the composition of the material, although very marked by the absence of fossils. A number of sections in the west manifest precisely the same fact. It may be seen in almost any pit at Paisley. Through the undulations of the boulder clay, at the base of the series (before alluded to), the measurements of this bed vary considerably; and even in the same pit its depths may differ by many feet.

Nothing can be more striking, then, than the general physical analogy between the section at Errol and a good typical section in the Clyde district.

The Errol clay contains certain species of shells not found in the west, mixed with others entirely identical; and the high northern character of these peculiar species may either indicate a slight precedence

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in time of the eastern beds, and consequent prevalence of a sterner climate, or be explained by local peculiarities of depth and exposure.

The remarkable conformity, however, between the two series of clays, in their sequences and characteristics, unmistakably proves that they must have been formed by the exercise of the same physical forces, acting under the same conditions, and with similar degrees of persistency and power. The phenomena of the glacial epoch cannot be summarily disposed of under the terms "drift" and "boulder clay." There are divisions and subdivisions yet to be made, each, it may be, involving mighty periods in the history of the globe.

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MINUTES.

Anderson's University Buildings, November 4, 1863.

THE Sixty-Second Session of the Philosophical Society of Glasgow was opened this evening. In the absence of the President, Dr. Thomas Anderson was called to the Chair.

Dr. Anderson delivered an opening address. After reviewing the proceedings of last Session, he remarked on the circumstance that although the Society had increased in the interest and importance of its business, the number of its members continued from year to year to be somewhat less than 300. This, he said, was to be ascribed not to any want of appreciation of the Society, but to its having in the course of years been the parent of several other scientific institutions. When the Philosophical Society originated, there was no other Society in Glasgow where men of congenial tastes could meet for the interchange of scientific knowledge; but as the number of such persons increased they hived off, and formed other Societies for the prosecution of their special objects. This had proved fatal to the operation of the former plan of dividing the Society into sections, and had caused the failure subsequently of a modification of the sections, by appointing committees to report on the progress of various branches of science. The latter plan had, indeed, produced some valuable reports; but it had not been so successful on the whole as had been anticipated, and had now to a great extent fallen into abeyance, so difficult was it often found to work out in practice what might appear to be a very desirable system. There are many points on which the Society might exercise a very important influence. In the midst of a commercial community, the members might do much to encourage and develop the progress both of science and commerce. Opportunities were of constant occurrence for bringing their influence to bear on the practical application of science, whether commerce took a particular direction, and science followed, or, on the contrary, when science led and commerce followed. Dr. Anderson proceeded to illustrate at length the influence of commerce upon the progress of applied science, by showing how the demand for potash and its compounds had stimulated chemical discovery during the last half century.

On the motion of Mr. Charles Heath Wilson, a cordial vote of thanks was given to Dr. Anderson for his address.

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November 18, 1863.—JOHN HART, Esq., Vice-President, *in the Chair.*

The following gentlemen were elected members of the Society, viz.:—

Mr. William Mollison, Jun., Dyer, 70 Queen Street.
Mr. Henry Grierson, Manufacturer, 3 North Exchange Court.
Mr. James Muir, Merchant, 25 Queen Street.
Mr. Archibald Robertson, Merchant, 25 Queen Street.
Mr. James Thomson, 141 Hospital Street.
Mr. J. H. Bald, Chemist, Crawford Street Chemical Works.
Mr. John Burnet, Water Office, 23 Miller Street.
Mr. Thomas Ferguson, 275 St. George's Road.
Mr. Richard Moses, 49 Arlington Street.

Mr. William Cockey, the Treasurer, gave in the following Abstract of the Accounts for the past year:—

DR.		
1862.—*Nov.* 1.		
To Cash in Bank,	£13 9 6	
Do. in Treasurer's hands,	1 16 7	
		£15 6 1
1863.—*Oct.* 31.		
Entry-money from 22 new Members,	£23 2 0	
Annual Payments from 280 Members,	294 14 0	
		317 16 0
Rent from Institution of Engineers,		15 0 0
Surplus Proceeds of Converzatione in Queen's Rooms,		22 19 0
Sale of Proceedings,		0 10 6
Interest on Bank Account,		1 10 11
		£373 2 6
CR.		
1863.—*Oct.* 31.		
By New Books,		£77 2 11
Printing Proceedings,		37 1 0
Printing Circulars, and Stationery,		17 7 0
Salaries and Wages,		116 4 5
Rent, Insurance, and Gas,		53 0 2
New Book Cases and Repairs,		43 0 3
Petty Charges,		4 7 4
Balance in Bank,	£23 0 11	
Do. in Treasurer's hands,	1 18 6	
		24 19 5
		£373 2 6

Dr. Bryce, the Librarian, reported that the Library now contains 3,528 volumes.

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The Society proceeded to the Sixty-second Annual Election of Office-Bearers, when the following were appointed:—

President.

Professor Henry D. Rogers, LL.D., F.R.S.

Vice-Presidents.

Professor William Thomson, LL.D., F.R.S.
Professor Allen Thomson, M.D., F.R.S.

Librarian.

James Bryce, LL.D., F.G.S.

Treasurer.

Mr. William Cockey.

Joint-Secretaries.

Mr. Alexander Hastie. | Mr. William Keddie.

Council.

Mr. George Anderson.	Mr. James M. Gale.
Mr. William Euing.	Prof. W. J. M. Rankine.
Mr. Walter M. Neilson.	Mr. James Napier.
Dr. Thomas Anderson.	Mr. Robert Hart.
Mr. Alexander Harvey.	Dr. Francis H. Thomson.
Mr. Thomas M'Guffie.	Dr. John Taylor.

Dr. John Taylor read a paper entitled, "The History of the Optical Illusion called the Ghost," illustrated by apparatus of his own contrivance, and received a hearty vote of thanks from an unusually large meeting.

December 2, 1863.—Dr. Allen Thomson, *Vice-President, in the Chair.*

The following gentlemen were elected Members of the Society, viz.:—

Dr. W. T. Gairdner, Professor of Practice of Physic, University of Glasgow.
Mr. Robert Stevenson, 2 West Regent Street.
Mr. John Binning, Manufacturing Chemist, 103 St. Vincent Street.

Schiele's patent Turbine Water Wheel, exhibited by Mr. Gale, was, in his absence, described by Mr. J. R. Napier.

On the recommendation of the Council, the Society agreed to add £5 to the annual Salary of James M'Lagan, the Sub-Librarian.

The Theory of Jones's method of controlling Clocks by Electricity was explained and illustrated experimentally by Professor William Thomson. The subject gave rise to a discussion, in which Mr. Provan, Dr. Pritchard, Dr. Allen Thomson, and others, took part, on the comparative merits of time-guns and electrically-regulated clocks.

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December 16, 1863.—Dr. John Taylor *in the Chair.*

The following gentlemen were elected Members of the Society, viz.:—

Mr. Francis Murray, Monkland House.
Dr. William Lyon, 227 West George Street.
Mr. James R. Thomson.
Mr. John R. Irvine, Manufacturing Chemist, Port-Dundas.

Mr. Gale described Schiele's Turbine, and exhibited the machine in operation.

Mr. Wünsch read a paper "On the Utilization of Sea-weed." The subject gave rise to some discussion, in which Mr. Ramsay of Kildalton, Mr. Downie, Mr. J. R. Napier, and other Members, took part.

The Rev. Francis P. Flemyng read a paper "On the Fossil Conchology of the Clyde," illustrated by specimens of Post Pliocene Shells collected at Fairley.

January 13, 1864.—Professor William Thomson *in the Chair.*

The Rev. James Dodds, of St. Stephen's Church, Glasgow, was elected a Member.

Professor Grant gave an account of the method of ascertaining Astronomical Time for the Regulation of Clocks.

January 27, 1864.—Dr. Allen Thomson *in the Chair.*

Mr. John Burns, Surgeon, 132 Greenhead Street, was elected a Member.

Mr. Crosskey exhibited a specimen of Coal from the neighbourhood of a Trap Dyke, showing the columnar form; a specimen of Mica Schist from the Vitrified Fort in the Kyles of Bute, showing the same form; and a similar example of columnar sandstone from an iron furnace.

A Clock with a Jones's Pendulum was exhibited to the Society; and Professor William Thomson and Professor Grant gave further explanations on the controlling of Clocks by Electricity.

February 10, 1864.—Professor Rogers, *the President, in the Chair.*

Mr. William Henry Hill, 1 South Frederick Street, and Mr. Edward C. C. Stanford, were elected Members.

Mr. C. Heath Wilson read a paper, entitled, "Memoir of the Cathedral Windows."

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REPORT OF COMMITTEE ON PATENT LAWS.

MR. COCKEY, as Convener of the Committee nominated to consider the Questions proposed by the Royal Commissioners appointed to inquire into the operation of the Patent Laws, gave in the following Report:—

GLASGOW, *November* 18, 1863.—The Committee having met and considered the various Queries proposed by the Royal Commissioners, beg to submit the following Replies:—

"I. Should the cost of obtaining Letters Patent be diminished or increased? if either, to what extent? and should the payment be made in one sum, or by annual or other instalments?"

There do not appear to be sufficient reasons for materially altering the preliminary cost of obtaining Letters Patent; but we think that the sum of fifty pounds, now payable at the end of the third year, should not be exacted till the end of the fifth year, and that no further payment should afterwards be required.

"II. Does the present mode of obtaining Patents appear to you satisfactory? Is it your opinion that there ought to be a preliminary investigation of a more searching character than that which at present takes place? If so, how should the tribunal be constituted before which such investigation shall be conducted, and should the judgment of such tribunal be final?"

The present system of obtaining Letters Patent is undoubtedly not satisfactory. We are of opinion that there should be a preliminary investigation as to novelty, the result of such investigation being made public, but not to be absolutely final.

"III. Should the investigation be *ex parte* or public, and subject to opposition? Should the present practice as to caveats be adhered to?"

Our reply to the last question disposes of this one, except as regards opposition, with respect to which we think that the facilities at present granted to intending opponents have been so little taken advantage of that it is doubtful if increased facilities are necessary.

"IV. Have you reason to suppose that public inconvenience is caused by the multiplicity of Patents?"

Yes.

"V. Do you consider that Patents ought to be refused on the ground of the trifling and frivolous nature of the Inventions for which they are claimed?"

Yes, if any practical method can be found for deciding on what are frivolous inventions.

"VI. Should greater facilities be provided for the repeal of invalid Patents?"

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Yes, to the extent of reducing costs of proceedings for obtaining such repeal.

"VII. Do you consider that any change should be made in the tribunal appointed to try actions and suits instituted by Patentees?"

We are of opinion that the juries appointed to try Patent Cases should be composed exclusively of scientific and practical men, conversant with the subjects in dispute.

"VIII. Should the granting of Licences, in your opinion, be made compulsory; and can you suggest any practicable method by which this should be done?"

We do not see our way to suggest any practicable system of compulsory Licences; but we think that such a system would be very desirable if a suitable one could be found.

"IX. Do you think it expedient that Patents should be granted to importers of Foreign Inventions?"

"X. Do you think it expedient that Patents should be granted to Foreigners residing abroad, or to their nominees?"

The following answer will apply to both:—We think that Patents should still be granted for Foreign Inventions, but that means should be taken to insure the granting the privilege strictly to the original inventor, or to parties properly deriving their rights from him.

"XI. Is it expedient to make any, and, if so, what alterations in the law relating to prolongations and confirmations?"

"XII. Is it expedient to make any, and, if so, what alterations in the law respecting disclaimers and memoranda of alterations?"

Something may probably be done to cheapen the cost of these proceedings.

The Report was unanimously approved of by the Society.

Professor Grant explained the method of determining true time employed at the Observatory of the Glasgow University, and the process by which Greenwich mean time is transmitted to the city of Glasgow.

February 24, 1864.—Professor Rogers, *the President, in the Chair.*

Mr. Alexander Whitelaw read a paper "On a Practical Application of Dialysis to the Utilization of the Waste Brine of Salted Meat."

The President exhibited a slab of Indurated Clay from a brickfield near Dunbar, containing numerous specimens of *Ophiolepis gracilis*, Allman, a species of star-fish still found living. The layer of clay containing the Ophiolepis is about half an inch thick, and can be traced along the edge of the excavation in the deposit for nearly a hundred yards. It

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lies about six feet below the surface of the brick clay. Its elevation above the tide is not great; indeed, the high tides of the present time would overflow the fossil layer if it were not for an embankment. Horns of deer and other ruminants have been discovered in the clay above the star-fish bed.

March 9, 1864.—DR. ALLEN THOMSON, *Vice-President, in the Chair.*

PROFESSOR GRANT made a supplementary statement on the Regulation of Clocks by Electricity, and the results of the connection established betwixt the Observatory and the College Clock.

MR. C. GREVILLE WILLIAMS read a paper "On Explosive Compounds and Modern Projectiles," illustrated by drawings and numerous experiments.

The thanks of the Society were communicated to Mr. Williams by the Chairman, who took occasion to express the good wishes of the Members for his success in the new sphere of labour to which he is about to remove.

March 23, 1864.—ALEXANDER HARVEY, Esq., *in the Chair.*

Dr. Alexander Greenlees, 405 St. Vincent Street, was elected a Member.

DR. BRYCE gave a description of the Glacial Phenomena of the Lake District of England.

DR. MATHIE HAMILTON, formerly Medical Officer to the London, Potosi, and Peruvian Mining Company, made a communication, entitled, "Remarks on the Great Lakes Titicaha and Aullaga, in Upper Peru and Bolivia, with Observations on their Drainage."

April 6, 1864.—PROFESSOR WILLIAM THOMSON *in the Chair.*

Mr. George John Doddrell, 4 Buckingham Terrace, and Mr. Thomas Hannay, 43 West Regent Street, were elected Members.

Mr. John Ure having been called to the Chair, PROFESSOR WILLIAM THOMSON gave an account of the Periodic Variations and the Secular Lowering of Terrestrial Temperature.

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April 20, 1864.—*The concluding Meeting of the Society was held this evening,* Professor Rogers, *the President, in the Chair.*

Mr. John Gray, 150 West George Street, was proposed as a Member by Dr. Scouler, Mr. James Armstrong, and Mr. W. Keddie.

The Council reported that a letter had been received from Mr. Wm. Cockey, resigning the office of Treasurer to the Society. In accepting of the resignation, the Council agreed to record their thanks to Mr. Cockey for his past services. The Council also agreed to request Mr. William Ramsay to act as Interim-Treasurer till November. Mr. Ramsay being present, intimated his compliance with the request of the Council, and was authorized to receive the Treasurer's books from Mr. Cockey, and to have the funds of the Society in Bank transferred in his name.

The following papers were read, viz.:—

Mr. William Gorman,—"A few Practical Remarks on the Prevention of Smoke."

Rev. Mr. Crosskey,—"The Relation between the Glacial Clays of the East and West of Scotland."

Mr. William Johnston,—"On the Discovery of the Skeleton of a Whale in the Valley of the Forth, near Stirling."

Mr. William Keddie,—"Note on the alleged Excessive Occurrence of *Acarus sacchari*, or Sugar Mite, in Raw Sugar." The result of numerous examinations of the ordinary sugars of commerce showed, that in none of them does the mite occur to the extent represented in a printed statement lately circulated amongst Members of Parliament.

In closing the proceedings, the President congratulated the Society on the varied and interesting nature of the subjects which had been brought forward during the Session, and on the large accession of new Members. He hoped that in following their different pursuits in the course of the summer, the Members would keep in view the work of the next Session, when the Society would be glad to receive the results of their investigations.

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